The Afghanistan Engineering Support Program assembled this deliverable. It is an approved, official USAID document. Budget information contained herein is for illustrative purposes. All policy, personal, financial, and procurement sensitive information has been removed. Additional information on the report can be obtained from Firouz Rooyani, Tetra Tech Sr. VP International Operations, (703) 387-2151.

USAID | AFGHANISTAN
FROM THE AMERICAN PEOPLE

ENGINEERING SUPPORT PROGRAM

WO-LT-0054 Amendment 1 Final Report
Reactive Power Compensation (RPC) Technical Section for the Kabul to Kandahar East Transmission Line

September 13, 2012
This publication was produced for review by the United States Agency for International Development. It was prepared by Tetra Tech, Inc.

This report was prepared for the United States Agency for International Development, Contract No. EDH-I-00-08-00027-00, Task Order 01, Afghanistan Engineering Support Program.

Principal Contacts:

[redacted]
VP International Operations
Tetra Tech, Inc.
Washington, DC
[redacted]

[redacted]
Senior Vice President
Tetra Tech, Inc.
Framingham, MA
[redacted]

[redacted]
Project Manager
Tetra Tech, Inc.
Framingham, MA
[redacted]

[redacted]
Chief of Party
Tetra Tech, Inc.
Kabul, Afghanistan
[redacted]

TETRA TECH

September 13, 2012

[redacted]R
[redacted] ACOR
USAID – Office of Economic Growth and Infrastructure (OEGI)
Café Compound
U.S. Embassy
Great Masood Road Kabul, Afghanistan

Re: WO-LT-0054 Amendment 1-Reactive Power Compensation (RPC) Technical Section for the Kabul to Kandahar East Transmission Line

[redacted]

Enclosed is the final report for the subject work order deliverable. Tetra Tech has already delivered the final reports for a) WO-LT-0054 Reactive Power Compensation (RPC) Technical Section for the Pul-e-Khumri to Kabul Transmission Line and b) WO-LT-0054 Reactive Power Compensation (RPC) Design Analysis Pul-e-Khumri to Kandahar East.

I look forward to meeting with you at your convenience to discuss this report.

Respectfully,

[redacted]
Chief of Party (AESP)
Tetra Tech, Inc.

Cc: [redacted]ID-OEGI)
[redacted](USAID-OEGI)

AFGHANISTAN ENGINEERING SUPPORT PROGRAM

WO-LT-0054 Amendment 1
Final Report
REACTIVE POWER COMPENSATION (RPC) TECHNICAL SECTION FOR THE KABUL TO KANDAHAR EAST TRANSMISSION LINE

September 13, 2012

1.0 Executive Summary

Approach

This report provides a technical scope of work (generally known as Volume 2 of 3) for procurement of the final design and installation of Reactive Power Compensation (RPC) improvements for transmission line and substations between Kabul and Kandahar East. These RPC improvements coincide with the initiative generally known as the Power Transmission Expansion and Connectivity (PTEC) program. This document has been prepared by Tetra Tech under the Afghanistan Engineering Support Program (AESP) with USAID, work order WO-LT-0054 Amendment 1.

This report includes supporting engineering documents (drawings and specifications) that may be incorporated into a request for proposal (RFP) to procure RPC design and construction services. Sufficient information is provided for a competent design build (DB) or engineer/procure/construct (EPC) firm to accomplish final design and construct the system.

This technical scope of work document provides sufficient technical information for a competent DB or EPC firm to perform final design, and to construct appropriate RPC from Kabul to Kandahar East. To the extent practicable, the technical scope of work (Volume 2 of 3) has been structured to follow the DABS example RFP format.

Consultation and Background Information

Consultation

The project team consulted with Afghanistan energy sector organizations including Da Afghanistan Breshna Sherkat (DABS) and Ministry of Energy and Water (MEW) to ensure the work product would be compatible with the proposed DABS "on-budget" procurement process supported by USAID. Consultation included meetings with DABS and USAID management, preliminary draft document reviews, and a wealth of email communications among interested parties to resolve minor technical issues and provide scope clarification.

Specification Reviews

Previously issued RFP packages used successfully by DABS in the past were provided to the project team as examples. The RFP examples were used in the development of this technical specification document as follows:

1. Design, Supply, and Installation for Kunduz – Taloqan 220 kV Transmission Line Project Tender No. :DABS/OO1/ICB
2. RFP for Northeast Power System (NEPS) Electrical Transmission Projects, Afghanistan (US Army Corps of Engineers)
3. Asian Development Bank (ADB), Power Transmission and Distribution Project ADB Loan No. 2165-AFG(SF)/Grant 0004-AFG(SF); Supply, Delivery and Installation Contracts for Lots 1 & 2, Bidding Documents, June 2005

Engineering Study

Technical data has been developed for use in the Kabul – Kandahar East RPC technical specification document (Volume 2) by performing the following studies:

- The system was modeled in PSS/E, based on an evolving model used in previous work orders (LT-0021, LT-0048, LT-0051, and LT-0053).
- Power flow studies were run to discern the system conditions that required the most RPC; this is the "controlling system."

- Dynamic and time-domain studies were run with appropriate RPC modeled, to confirm the system operated within specified limits.
- Various contingency situations were modeled, to simulate inoperable components and failures along the system. This confirmed the proposed RPC system was robust enough to withstand reasonable contingency scenarios.

The specified RPC system includes fixed series capacitors (FSCs), mechanically switched capacitors (MSCs), and static VAR compensators (SVC) at various substation locations.

The objective of this document is to provide technical specifications for the RPC for the proposed 220kV transmission line from Kabul to Kandahar East. Installation of the RPC as specified will enhance the reliability and quality of power.

Findings

The proposed 220kV transmission line from Kabul to Kandahar East was modeled as a double-circuit line originating at Dasht-e-Barchi substation and terminating at Kandahar East substation, with seven intermediate substations along the 481km line route. Each circuit is modeled as two 'Zebra' conductors per phase. Total modeled load on this transmission line is 180MW. This is approximately the sum of all distribution substation transformers (130 MVA total) plus an additional 50 MVA of 110kV load served from Kandahar East substation.

Since the design analysis was performed, the following changes are being considered:

1. The additional proposed 160 MVA transformer at Chimtala SS will not be installed
2. The 220kV connection is no longer necessary at Dasht-E-Barchi (because Dasht-E-Barchi will not be constructed) but has moved 17.6km south west to a previously unknown substation located at Arghandi.
3. Arghandi will eventually have:
    - Two 50MVA - 220/110kV Transformers (which will connect 30km away at Kabul Breshna Kot)
    - Two 60MVA – 220/20kV Transformers for local distribution
    - One 60MVA -220/20kV Transformer for future local distribution
4. The Maydan Shar Substation and associated RPC will not be constructed.

Although changes in the proposed transmission line and location of substations since the PSS/E model was constructed are fairly significant, the design as it stands will function. However, further analysis will be required to determine the exact MW capabilities or design revisions needed to meet the previous requirements. An initial estimate is that changes would reduce the Kabul to Kandahar transmission line MW carrying capacity by 10%.

ISLAMIC REPUBLIC OF AFGHANISTAN

DA AFGHANISTAN BRESHNA SHERKAT (DABS)

INTERNATIONAL COMPETITIVE BIDDING

For

DESIGN, SUPPLY AND INSTALLATION FOR NORTHEAST POWER SYSTEM REACTIVE POWER COMPENSATION

TENDER No. : DABS

VOLUME 2 OF 3

SEPTEMBER 2012

Table of Contents - Summary Description

Preface

The Bidding Document released by DABS for procurement of Plant – Design, Supply and Installation, is based on the Standard Bidding document for Procurement Plan - design, Supply and Install (SBD plant, single stage, two envelope) commonly issued by the Asian Development Bank.

DABS’s SBD Plant has the structure and the provision of the Master Procurement Document “Procurement of Plant – Design, Supply and Install”, prepared by multilateral development banks and other public international financial institutions except where DABS – Specific considerations have required a change.

Acronyms

ACSR	Aluminum Conductor Steel Reinforced
ADM	Add / Drop Multiplexing
AIF	Afghanistan Infrastructure Fund
AMSL	Above Mean Sea Level
ANSI	American National Standard Institute
AP	Angle Point
ASA	American Standards Associaton (ANSI)
ASCE	American Society of Civil Engineers
ASTM	American Society of Testing and Materials
BS	British Standard
BU	Bay Units
CSCS	Computerized Substation Control System
DBPC	Di-tert-butyl-para-cresol
DC	Double Circuit Tower Type – C (Tension)
DD	Double Circuit Tower Type – D (Tension)
DIN	Deutsches Institute für Normung e.V.
DNP	Distributed Network Protocol
DXC	Digital Cross Connect
FAT	Factory Acceptance Testing
FC/PC	Fiber Connector for Physical Contact
FDS	Functional design specification
FSC	Fixed Series Capacitors
HMI	Human Machine Interface
HV	High Voltage
IEC	International Electrotechnical Commission
IED	Intelligent Electronic Devices
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Standards Organization
ITB	Instruction to Bidders
ITU-T	International Telecommunication Union Standard T (ITU's Telecommunication Standardization Sector)

kA	kilo Amperes, 1000 A
kg	kilogram
kN	kilo Newton, 1000 N
kV	kilo Volt, 1000 V
kVArh	kilo Volt Amperes Reactive hours).
LARP	Land Acquisition and Resettlement Plan
L/R	Slenderness ratio, length / radius
Lux	light intensity measurement
m a.m.s.l.	meters above mean sea level
MCCB	Molded Case Circuit Breaker
MEW	Ministry of Energy and Water – Govt. of the Islamic Republic of Afghanistan
MMC	Man Machine Communications
MHz	mega Hertz
MOF	Ministry of Finance – Govt. of the Islamic Republic of Afghanistan
MOI	Ministry of Interior – Govt. of the Islamic Republic of Afghanistan
MOSS	Minimum Operating Safety Standards
MOV	Metal Oxide Varistor
MSC	Mechanically Switched Capacitors
MSS	Mechanically Switched Shunt
MSR	Mechanically Switched Reactors
MVA	mega Volt ampere
MW	megawatt
N	Newton
NEPS	Northeast Power System
NLCC	National Load Control Center
NMS	Network Management System
No.	Number
ODAF	Oil Directed Air Forced cooling
OLTC	On-load tap changer
ONAF	Oil Natural Air Forced cooling
OPGW	Optical Fiber Ground Wire
PABX	Private Automatic Branch Exchange

PCC	Plain Cement Concrete
PSTN	Public Switched Telephone Network
QSIG	Q signaling
RCC	Reinforced Cement Concrete
RFP	Request for Proposal
RF	Radio Frequency
RTU	Remote Terminal Unit
RoW	Right of Way
SCADA	Supervisory Control and Data Acquisition
SDH	Synchronous Digital Hierarchy
SEPS	Southeast Power System
SI	System International
SINAD	signal to noise and distortion ratio
SOH	Section Overhead
SVC	Static VAR Compensator
U_n	Nominal Voltage
U_m	Design Voltage
U_{max}	Maximum Voltage
UNMACA	United Nations Mine Action Center, Afghanistan
UTM	Universal Transverse Mercator
UTS	Ultimate Tensile Strength
UXO	Unexploded Ordinance
VA	volt ampere
VAC	Volt alternating current
VDE	Verband Der Electrotechnik Electronik Informationstechnik e.v
VF	Voice Frequecy
VHF	Very High Frequency
XLPE	Cross –linked polyethylene
μm	micro meter (1x10-6 m)

Section 6

Employer's Requirements

Contents

Appendix

List of Tables

1.0 Security at Site

1.1 Security Plan and Implementation

Site security planning and implementation shall be coordinated with and conform to the requirements of AESP WO-LT-0048.

No additional security requirements are required by this specification.

2.0 Technical Specification

2.1 Project Description

2.1.1 Overview

The existing Northeast Power System (NEPS) includes a 220kV transmission line system that transports power from Uzbekistan and Tajikistan to Pul-e-Khumri Substation (SS) in northern Afghanistan and from there over the Salang Pass to the Chimtala SS on the northern outskirts of the City of Kabul.

Efforts are currently underway “by others” to provide a new substation at Arghandi, southwest of the City of Kabul, and extend the 220kV transmission system south from the Chimtala Substation to Arghandi SS.

AESP WO-LT-0048 provides a technical specification for procurement of a duplex conductor 220kV double circuit transmission line system from Arghandi Substation along the ring road to substations at Saydabad, Ghazni City, Qarabagh, Gelan (Moquar), Shah Joy, Qalat, and Kandahar East.

The WO-LT-0048 transmission line works covers the construction of approximately 500 km of 220kV double circuit transmission line from the proposed 220kV substation at Arghandi (constructed by others) to the new 220kV substation at Kandahar East.

This document, prepared under AESP WO-LT-0054, provides technical sections (Specifications) for the design, procurement, construction, and commissioning of Reactive Power Compensation (RPC) equipment to support operation of substations and transmission lines specified under WO-LT-0048. The objective of this work is to enhance the operability, reliability, power quality and capacity of the 220kV transmission line system described under WO-LT-0048..

Relatively small changes in active (real) and reactive power at the Chimtala SS could cause relatively large changes in the bus voltage at Kandahar East SS. These large voltage changes at Kandahar East SS could even cause system collapse due to low voltage or system protective relay action due to high voltages. This tendency will be mitigated by the addition of a Static VAr Compensator (SVC) in the Kabul area under a separate procurement (See AESP WO-LT-0054 Reactive Power Compensation (RPC) Technical Section for the Pul-e-Khumri to Kabul Transmission Line). However, the RPC on the Kabul to Kandahar East transmission line system must be able to manage reactive power flow to minimize the impact to power quality and risk of outages due to over/under voltage should the SVC in Kabul be out of service. When the SVC in Kabul is in service the RPC must provide for stable voltages within acceptable limits at the Kandahar East Substation and acceptable voltages to all of the remaining substations and transmission lines under varying loading conditions as specified under WO-LT-0048.

2.1.2 Base Bid

Design, procure, construct, and commission RPC equipment for the 220kV transmission line from Arghandi SS to Kandahar East SS.

The Arghandi SS to Kandahar East SS transmission line system may be built in segments from which the Employer may select segments to be built. The contractor shall assume that the transmission line system will be constructed with all segments selected (double circuit / duplex conductor extending from Arghandi SS to Kandahar East SS).

Included in the scope of WO-LT-0054 Amendment 1 are the design, procurement, construction, and commissioning of new RPC systems to support reliable power delivery from the Arghandi SS to Kandahar East SS with loads distributed to locations as shown in Table 2.1. RPC system designs shall be coordinated with WO-LT-0048 and shall be located approximately as shown in WO-LT-0048 Section 4.0E conceptual design drawings.

Table 2.1 Substation Locations and Transformer Loads

Location	Voltage	Transformer Loads	Jacobs Engineering Substation Plan Section 4.0E	Approximate Location	Approximate Elevation
Maydan Shar	220kV	1 x 10MVA	Plan E	34.39444N, 68.87167E	2,225m
Sayabad	220kV	1 x 10MVA	Plan D	33.98765N, 68.70842E	2,129m
Ghazni City	220kV	2 x 10MVA	Plan A	33.56311N, 68.44222E	2,201m
Qarabagh	220kV	1 x 10MVA	Plan D	33.177518N, 68.137267E	2,063m
Gelan (Moquar)	2 x Dead End Towers for Future Substation Construction			32.81645N, 67.76452E	1,999m
Qalat	220kV	1 x 10MVA	Plan D	32.10600N, 66.90154E	1,575m
Kandahar East	220kV	5 x 10MVA	Plan A	31.60357N, 65.76561E	1,000m
	110kV	1 x 50MVA			

RPC equipment for each substation location shall be sized as indicated in Table 2.2 and supplied in compliance to these specifications.

Table 2.2 RPC Equipment Type, Sizing, and Location

Substation	Equipment Type	Bank Sizing	Connected Bus Voltage
Maydan Shar	MSR	1 x 15MVAr	220kV
Sayabad	MSR	1 x 15MVAr	220kV
Ghazni City	MSR	2 x 15MVAr	220kV
Qarabagh	MSR	2 x 20MVAr	220kV
Gelan (Moquar)	MSR	-	220kV
Qalat	MSR	2 x 20MVAr	220kV
Kandahar East	MSR	2 x 15MVAr	220kV
	SVC	From +20MVAr through-20MVAr (capacitive to inductive) Continuous rating From +25MVAr through-35MVAr Dynamic rating	220kV

The bid, hereinafter referred to as "the Works", shall include the complete design, construction, test, and provision in full working order (including all appurtenances and spare parts required) in the bid as required in these specifications. The Contractor shall execute all temporary and permanent works, whether particularized in these Specifications or not, necessary for a timely and successful Taking-Over (possession and control by the Employer/Owner) of the Works. The Taking-Over shall be within 36 months from the date of commencement of the Works.

Pricing shall include:

- Design of an RPC system to support reliable operation of a complete duplex conductor 220kV double circuit transmission system.
- Installation of RPC equipment with capacity and location as indicated in Table 2.2.
- Preparation of all required system drawings including, but not ??limited to, site plans, installation details, system one lines, control diagrams, and wiring schematics.
- All required RPC equipment, control equipment, communication systems, protection, software, programming, structures, and civil works required for reliable operation of the 220kV transmission system within the power quality constraints defined in this Specification.
- Line item pricing breakdown for design services, procurement, construction, and commissioning of RPC equipment and enclosures (SVC and line reactors) to be installed at each substation location. Pricing shall clearly indicate the substation name, equipment type, equipment sizing, and installed cost of each reactor bank or SVC system.
- Procurement, construction, and commissioning of a complete RPC system (structures, protection, equipment, controls, software, and programming) to support reliable operation of the 220kV duplex conductor single circuit.

RPC for “future” circuits shall not be considered.

2.1.3 Bid Options

2.1.3.1 Bid Options

The Employer will select segments to be built from Arghandi SS to Kandahar East SS transmission line system after bid evaluation. Should the options deviate from construction of a double circuit /duplex conductor transmission line extending from Arghandi SS to Kandahar East SS, additional analysis will be required to size and optimize placement of RPC equipment for the system.

The Contractor shall price analysis of the Arghandi SS to Kandahar East SS transmission line system for a single variant of the Arghandi SS to Kandahar East SS transmission line system 220kV system configuration. The analytical study will evaluate a single subset of the line segments identified, based on segments elected by the Employer.

2.1.3.2 The analysis shall include:

- Power flow and dynamic analyses using Siemens/PTII PSS/E software of the transmission line segments elected by the Employer.
- Any additional studies determined to be necessary by the Contractor.
- Prescriptive determination and specification of RPC equipment to be installed at each substation location.

- Preparation of a study report, documenting the studies performed and demonstrating that the designed RPC system will maintain steady state and dynamic voltages and power flows within allowable limits for steady state and contingency conditions established in this specification.

- The PSS/E study and report shall be fully coordinated with the substation and transmission line design activities.

- The study report shall be prepared in compliance with the requirements of this specification.

2.1.4 General

This scope of work for the RPC system Design, Manufacture and Supply, Construction, Erection, Installation, Testing and Commissioning includes the following components:

A. Provide detailed design, procurement, construction, and commissioning services for new RPC facilities including equipment and control enclosures, RPC equipment, substation structures, equipment pads, control equipment, lines, cables, and supporting equipment required to support operation of the 220kV transmission line.

B. Coordinate RPC system design with substation designs at Sayabad, Ghazni City, Qarabagh, Shah Joy, Qalat, and Kandahar East.

C. The RPC system design shall include backup power storage and / or generation as required to support safe and reliable operation of the RPC system.

D. Site locations and orientations provided in this specification are approximate. The Contractor shall coordinate all final construction site locations with the Employer.

E. Design and construction of fencing and barriers to restrict access to reactor and capacitor banks.

F.The contractor shall design, specify, install, and commission protective relay and breaker systems to protect the RPC system components.

G. Metal Oxide Varistor surge arrestors shall be designed, specified, and installed to provide lightning protection to the RPC system.

H. Wiring diagrams / schematics shall be provided for all control and breaker cabinets.

I. The Employer reserves the right to videotape any all portions of the RPC system construction and commissioning for use in subsequent worker training activities.

2.2 General Requirements

2.2.1 Codes, Standards, and Specifications

All material used, plant supplied and all workmanship and tests shall be in accordance with the latest editions of IEC and ISO Standards, or where International Standards are not applicable, with national standards such as ASA, ANSI, ASTM, BS or VDE + DIN, IEEE, ASCE. Where such standards and codes are national or relate to a particular country or region, other authoritative standards that ensure substantial equivalence to the standards and codes specified or in accordance with technical requirements of a Country where the site is located, will be acceptable. For any such standards which are not written in the English language, the Contractor shall make available copies of a certified English translation thereof.

Where no standards exist, as in the case of patent or special materials, all such materials and workmanship shall be of the best quality, and full details of the material and any quality control tests to which they may be subjected, shall be submitted to the Engineer for approval.

The Contractor shall deliver (soft copy and hard copy) at his own cost, one complete set of the selected and approved international code standards, and specifications to the Employer / Engineer within 28 days after commencement of the works. The set shall contain codes, standards and specifications as referred to in the technical specifications or approved alternatives. One set shall be kept at the Contractor's site office and shall be accessible to the Employer or his representatives during working hours.

2.2.2 Plant and Materials

All plant and materials to be incorporated in the works must be new, unused, and of the most recent or current models, and must incorporate all recent improvements in design and materials unless provided for otherwise in the Contract. Where applicable, all plant shall be of design suitable for adverse climatic conditions as experienced on site in Afghanistan. All plant shall be inspected and tested in full, to prove compliance with the requirements of the Specifications to the satisfaction of the Engineer.

2.2.3 Workmanship

All work, method statements of work and workmanship, whether fully specified herein or not, shall be of the highest order. In all respects, the generally accepted requirements and commonly recognized good practice for first-class work of this nature are to be adhered to and the Contractor shall submit quality certificates for materials. Method statements shall be submitted for all works for review and approval before the work commences and shall be to the satisfaction and approval of the Engineer.

2.2.4 Design and Engineering

The Contractor shall design, manufacture, supply, erect, construct, install, test and commission all Plant and Materials, items and components of the Works, and carry out all installation services and work necessary so that the Works described herein shall be satisfactory for their intended purpose.

The Contractor shall design the complete Works in accordance with the design criteria and specifications given in the Supply Requirements, and as shown in the bid drawings. All design carried out by the Contractor shall comply with these specifications and shall take into account all requirements of the Facilities and technical requirements of Afghanistan. The Contractor shall optimize the design of each component of the Works in order to achieve the most economic design. The Contractor shall be entirely responsible for all design carried out by him.

The Contractor shall inform themselves fully of the actual dimensions, levels, etc., of any other existing or proposed structures before commencing the manufacture of parts dependent on such data. The design calculations for each member forming part of the Plant shall be based on the most unfavorable combination of all the loads which the said member or part is intended to support or assist in supporting either permanently or temporarily. All design calculations shall be subject to the review and approval of the Engineer.

Where appropriate design criteria or specifications are not indicated in the supply requirements or shown in the Bid Drawings, then the Contractor shall carry out the design work in accordance with generally accepted engineering design theories, principles and criteria, to the satisfaction of the Engineer.

The Contractor shall provide the Employer with fully detailed design drawings, detailed design reports and design calculations relating to the Works. All design work shall be subject to the approval of the Employer, pursuant to the Conditions of Contract. Design drawings, design reports and design calculations shall be prepared and submitted in accordance with chapter Documentation of the General Requirements.

2.2.5 System Characteristics and Climatic Conditions

All plant shall be designed for efficient operation under Afghanistan's climatic conditions, which can be harsh with snow and ice in winter and hot and dusty conditions in the summer.

RPC system design conditions shall be as indicated in WO-LT-0048 Table 2.2.1 "Plant Design Conditions". Information that applies specifically to the SVC is contained in Section 3 of this report.

2.2.6 Language

The English language shall be used in all Contract documents and in all correspondence between the Contractor and the Engineer, and between the Contractor and the Employer.

2.2.7 System of Units

In all correspondence, in all technical schedules and on all drawings, metric units of measurement, System International (SI) system of units, shall exclusively be used:

Dimensions in meters and millimeters unless specified otherwise.

- The unit of mass is the kilogram (kg).
- The unit of force is the Newton (N).
- Angular measurement shall be in degrees, with 90 degrees comprising one right angle.

2.2.8 Documentation

2.2.8.1 General

All documentation including, but not limited to, documents, drawings, and vendor submittals shall be submitted for Employer and Engineer approval, tracked, and controlled pursuant to the requirements of WO-LT-0048 Section 2.2.8.

2.2.9 Progress Reports

Work plans, monthly programs and reports shall be provided by the Contractor. Work plans and reports shall be coordinated and integrated with the WO-LT-0048 progress reports.

2.2.10 Manufacture

Before commencing any manufacture of the Plant, the Contractor shall submit for the approval of the Engineer, the drawings of the manufacturers of the plant. After such approval has been given, the manufacture shall be planned and performed according to the Specifications and to the satisfaction of the Engineer.

The Engineer shall be afforded every opportunity to control and inspect the manufacture and testing of materials in the steelworks, rolling mills, foundries, factories etc., and their assembly in the workshops of the Contractor and his Subcontractors.

2.2.11 Site Regulations and Safety

The Employer and the Contractor shall establish Site regulations according to the General Conditions of Contract.

The Contractor shall provide appropriate training in handling plant and machinery to the workers and laborers before the commencement of work. All workers employed by the Contractor shall be insured against any accident.

2.2.12 Notices and Permits

The Contractor shall give the requisite notice and obtain any necessary approvals from the Government or Authorities. Authorities' Inspectors may be required in the case of excavations, trenching and (in particular) blasting operations; the Contractor shall pay for all permits required prior to and during the execution of the Contract, including those required for all temporary works.

2.2.13 Verification of Dimensions

Before work is commenced on any structural element required to be fabricated, or provided under this Contract, the Contractor shall verify by measurement on site, the relevant dimensions of all work previously completed.

2.2.14 Site to be Kept Tidy

Throughout the progress of the Works, the Contractor shall keep the site and all working areas in a tidy and workmanlike condition, and free from rubbish and waste materials. Other items, which at the present time are not required for use by the Contractor, shall be dispersed about the site in an orderly fashion, or shall be properly and securely stored.

The Contractor shall not mobilize and demobilize of any construction plant, materials, etc. from the site without the approval of the Employer or Engineer.

2.2.15 Site Supervisors

The Contractor shall provide the services of competent specialists to supervise the construction of the Works and erection / installation of Plant at the Site. The Contractor's Site Supervisors shall be given full responsibility and authority to negotiate and agree points arising out of the Works, in order that the Works may proceed with a minimum of delay. Directions and instructions given by the Employer or the Engineer to the Site Supervisors shall be interpreted as having been given to the Contractor.

2.2.16 Safety of Personnel

Safety of personnel shall be managed in compliance with the requirements of WO-LT-0048 Section 2.2.16.

2.2.17 Packing and Transport Marking

Packaging and marking shall conform to the requirements of WO-LT-0048 Section 2.2.17.

2.2.18 Corrosion Protection and Painting

2.2.18.1 General

Corrosion protection and painting shall conform to the requirements of WO-LT-0048 Section 2.2.18.

2.2.19 Structural Steel and Cast Iron

Structural steel and cast iron shall conform to the requirements of WO-LT-0048 Section 2.2.19.

2.2.20 Copper, Aluminum Alloys and Clad Steel

Copper and aluminum stranded conductor material shall conform to the requirements of WO-LT-0048 Section 2.2.20.

2.2.21 Marking

Marking shall conform to the requirements of WO-LT-0048 Section 2.2.21.

2.2.22 Concrete Works

Concrete works shall conform to the requirements of WO-LT-0048 Section 2.2.22.

2.2.23 Auxiliary Electrical Supply

The Contractor shall be entirely responsible for providing auxiliary electricity supplies needed on Site for construction and commissioning.

2.2.24 Temporary site Installation

The Contractor shall be entirely responsible for providing all temporary site installations of every kind that may be required for carrying out the works including the facilities concerning office, living accommodation, fenced storage areas, lockable sheds, installations for supply of industrial water, power and compressed air, etc. The Contractor shall plan all temporary site installations required for the works to the approval of the Engineer. After completion of the work, such temporary installations are to be removed and the site left clean.

All costs for the construction and/or supervision and the removal or handing over to the Employer of all temporary site installations shall be deemed to have been included in the price schedules.

2.2.25 Running Costs

The Contractor shall be entirely responsible for the running and maintenance costs throughout the period when the site works are being carried out, including all temporary site installation works.

The costs for running and maintaining the temporary site installations together with other running costs necessary for the satisfactory execution of the works shall be deemed to have been included in the price schedules.

2.2.26 Social Safeguards

The Contractor shall minimize the locations of RPC equipment in agricultural and populated areas. Where siting of RPC equipment in agricultural and populated areas is unavoidable, the equipment shall be positioned to completely avoid houses, structures, and interference with social and cultural assets. The Contractor's detailed site plans will be reviewed and approved by the Employer, in consultation with any affected people, after verification of its land acquisition impacts.

2.3 Technical Requirements - RPC Equipment

All RPC equipment shall be designed, manufactured, and installed in accordance with the latest edition of ASTM, IEC, NEMA, and IEEE standards. This includes the following main standards:

- ASTM D1535-01 Standard Practice for Specifying Color by the Munsell System.
- IEC 60099-4:2004 Surge Arresters—Part 4: Metal-Oxide Surge Arresters without Gaps for AC Systems.
- IEC 61954-2011 Power Electronics for Electrical Transmission and Distribution Systems Testing of Thyristor Valves for Static VAR Compensators.
- IEEE STD 1031-2011 IEEE Guide for the Functional Specification of Transmission Static VAR Compensators
- IEEE STD 519-1992 IEEE Recommended Practices and Requirements for Harmonic Control in Electric Power Systems.
- IEEE STD 693-1997 IEEE Recommended Practices for Seismic Design of Substations
- IEEE STD C37.1-1994 IEEE Standard Definition, Specification and Analysis of Systems Used for Supervisory Control, Data Acquisition, and Automatic Control.
- IEEE STD C37.30-1997 IEEE Standard Definitions and Requirements for High-Voltage Switches.
- IEEE STD C37.41e-1996 IEEE Standard Design Tests for External Fuses for Shunt Capacitors.
- IEEE STD C37.90 IEEE Standard for Relays and Relay Systems Associated With Electric Power Apparatus.
- IEEE STD C37.90-1989 (Reaff 1994) IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus.
- IEEE STD C57.19.00-1997 IEEE Standard General Requirements and Test Procedures for Outdoor Power Apparatus Bushings.
- NEMA 107-1993 Methods of Measurement of Radio Influence Voltage (RIV) of High-Voltage Apparatus.

All RPC equipment (capacitors, breakers, wire and cable, electrical bus, connection accessories, etc.), enclosures, structures, pads, safety equipment, signage, marking, access roads and associated civil works shall be of similar type and construction and fully conform to the specifications detailed in WO-LT-0048 Section 2.4

3.0 Static VAR Compensator

3.1 General Requirements

3.1.1 Description of Work

The intent of this Specification is to have the Contractor furnish and install a complete Static VAR Compensator (SVC) and any required harmonic filter/shunt capacitor banks. In addition, the SVC shall have a short term overload rating for short durations, less than 2 minutes. It is anticipated that this short time rating will not increase the size of the main step-up transformer. The main step-up transformer shall be rated for the steady state rating of the SVC. The SVC will be connected to a position in the Kandahar East Substation 220kV bus.

The Contractor shall provide with their proposal, project experience in providing SVC systems in undeveloped countries. Information provided shall include location, rating, voltage, and references with names and contact information.

These specifications cover the design, manufacture of equipment, construction, installation, testing, commissioning, warranting, training, and placing into successful operation a complete SVC facility. The Contractor shall provide all necessary design, materials, equipment, and construction to provide a complete “turnkey” installation. It is the intent of these specifications to describe the required and desired features and performance requirements of the SVC and define the interconnection requirements to the Kandahar East Substation. No attempt has been made to describe all details of the intended design. It is the responsibility of the selected Contractor to define, design, and construct all aspects of the turnkey installation whether or not specifically described in this specification. It is the intent to purchase the Contractor’s standard system design and installation, to the extent possible, with such modifications required to provide the functions and performance specified herein.

The SVC is important to the stability and integrity of the bulk transmission system in the area. Therefore, the Employer desires to pursue options to help ensure the availability of the SVC for its intended use. The location of the SVC and inexperience of the Employers operation and maintenance personnel require a design that emphasizes reliability, simplicity and ease of maintenance. Of primary concern are single contingency failures that have the potential to cause the entire output of the SVC to be interrupted for significant periods of time, such as a failure of the main step-up transformer, or require complex diagnostic and maintenance procedures. The Contractors proposal shall include, at a minimum, optional prices to address single contingency outage issues.

The SVC shall be designed so that the failure of any single component, except the main step-up transformer, shall not affect the performance requirements described in these specifications. The Contractor shall provide a system with all necessary component redundancy to ensure rapid return to service in the event of any major component failure.

The Contractor shall provide with their proposal, information on the process required to add capacity to the SVC. This information shall include all modifications to or replacement of equipment and controls that may be required.

3.1.2 Material and Services Furnished by the Employer

- Available system load flow and stability studies previously completed by the Employer or their contractors. In addition, the Employer will furnish to the selected Contractor electronic databases of the affected system in PSS/E format.
- Single line sketch for the SVC system is contained in Appendix A of these specifications.
- Geotechnical considerations shall be coordinated with the substation design specified in WO-LT-0048.

3.1.3 Material and Services Furnished by the Contractor

The Contractor shall furnish all materials and services required for completion of the work. This list shall not be construed to be a complete listing of requirements, but rather a general overview. The scope of supply for the SVC system shall include, is not limited to, the following:

A. Engineering, design, fabrication, shipping, assembly, testing and supply of the components of the SVC, its assemblies, and accessories necessary for connection of the SVC to the Kandahar East 220kV bus.

B. The high power semiconductor devices, as required, for reactor control and capacitor switching including their protection, control, monitoring and cooling systems.

C. Harmonic filters as required to meet the specified harmonic performance levels.

D. The SVC main step-up transformer(s).

E. All current transformers and voltage transformers required.

F. All necessary equipment for the protection, control, indication and measurement of the SVC including interfaces to the Employer’s SCADA system.

G. Sequence of events recorder and digital fault recorder to monitor the SVC and other substation equipment if required for trouble shooting of the SVC.

H. Building as required to house the SVC equipment, control and protection equipment, batteries, spare parts and cooling equipment, including HVAC and fire protection systems.

I. SVC yard and associated substation civil work (i.e. site development, clearing, grading, retaining walls, drainage, fill, etc.), SVC site fencing, gates and site security during construction.

J. All required foundations and structures for the SVC equipment.

K. Outdoor lighting system.

L. SVC yard grounding and connection to the existing substation ground grid.

M. Surge protection and lightning shielding.

N. AC and DC distribution, including protection, batteries and chargers, distribution panels, and transfer switches.

O. Primary and back-up station power source, location to be determined by the Contractor.

P. All special tools required for the assembly and maintenance of the SVC.

Q. Wiring, connection and assembly of all equipment, apparatus, components, equipment frames, racks and switchboard panels.

R. All drawings and instruction booklets necessary to construct, operate and maintain the SVC and associated equipment.

S. Sufficient training of Employer personnel to enable them to operate and maintain the SVC without further assistance from the Contractor.

T. Supervise and perform final checkout, startup and commissioning tests of all SVC apparatus and controls, and verify proper operation and functioning of same.

U. A warranty for all SVC related equipment and substation components including the enclosure.

V. Provide necessary post-construction landscaping to return the site to its original aesthetic state.

3.1.4 Site Information

Refer to WO-LT-0048 Section 2.4 of the specification for site information.

3.1.5 Site Conditions

Refer to WO-LT-0048 Section 2.4 of the specification and Table 3.1 for site conditions.

The information in Table 3.1 supplements the information contained in WO-LT-0048 and is to be used for bid preparation only. Contractor must independently develop the information to used in actual design, subject to review and approval of the Employer.

Table 3.1 Site Environmental Data

No.	Type of information	Value	Units
1	Site elevation above sea level	1000m	m
2	Maximum ambient – dry bulb thermometer	45	°C
3	Maximum ambient – wet bulb thermometer	8 (high average dewpoint for July)	°C
4	Minimum ambient air temperature	-15	°C
5	Maximum daily average air temperature	31	°C
6	Minimum daily average air temperature	-1	°C
7	Ice loading conditions (thickness)	12.7	mm
8	Maximum ground snow depth	1	m
9	Maximum frost depth	1	m
10	Maximum steady wind velocity	55	m/s
11	Wind gust factor or maximum wind gust	1.5	
12	Seismic zone and withstand data as per IEEE Std. 693	High	
13	Isokeraunic level	Refer to Table 2.2.1 in WO-WO-LT-0048	days/year
14	Dust concentration (or pollution level per IEC 60815-01)	C - Medium	
16	Solar radiation level	Refer to table 2.2.1 in WO-WO-LT-0048	
17	Ground resistivity	2000 Single soil layer	Ohm-m
18	Humidity	Refer to table 2.2.1 in WO-WO-LT-0048	

3.2 Performance Requirements

3.2.1 System Electrical Characteristics

The following power system characteristics apply at the Kandahar East Substation of the SVC. Minimum insulation requirements are also included. This information is to be used for bidding only. Contractor must independently develop data used in design, subject to review and approval of the Employer.

Table 3.2 System Electrical Characteristics and Minimum Insulation Requirements

No.	Type of information	Value	Units
1	Normal AC system voltage, line to line	Table 2.2.1	kV
2	Maximum continuous ac system voltage, line to line	242 (1.1 pu)	kV
3	Minimum continuous ac system voltage, line to line	187 (0.85 pu)	kV
4	Maximum short-term ac system voltage, line to line	1.35 pu	kV
5	Maximum duration of item 4)	1	s
6	Minimum short-term ac system voltage, line to line	44 (0.2 pu)	kV
7	Maximum duration of item 6)	1	s
8	Continuous negative-sequence voltage component (used for performance calculation)	5	%
9	Continuous negative-sequence voltage component (used for rating calculation)	5	%
10	Continuous zero sequence voltage component	5	%
11	Nominal ac system frequency	Table 2.2.1	Hz
12	Maximum continuous ac system frequency	52.5	Hz
13	Minimum continuous ac system frequency	47.5	Hz
14	Maximum short-term ac system frequency	52.5	Hz
15	Maximum duration of item 14)	long term	
16	Maximum rate of change of frequency (df/dt)	0.2	Hz/s
17	Minimum short-term ac system frequency	47.5	Hz
18	Maximum duration of item 17)	Long term	
19	Basic insulation level	1050	KV peak
21	Power frequency withstand voltage	460	460
22	Maximum three-phase fault current - For performance requirement - For rating of SVC (See item 8.1.k)	 0.950 5	 kA kA
23	Existing three- phase fault current	0.950	kA
24	Minimum three-phase fault current - For performance requirements - For safe operation of SVC	 0.500 0.500	 kA kA
25	Maximum single-phase fault current	5	kA
26	Existing single-phase fault current	0.800	kA
27	Minimum single-phase fault current	0.400	kA
28	Harmonic background	Contractor to nominate value	-----------------

3.2.2 Rating and Performance

A. The Contractor shall provide any capacitor banks required for SVC rating and harmonic filtering.

B. The Contractor shall provide a temporary dynamic rating for the SVC for times less than 2 minutes. It is anticipated that the main step-up transformer will be designed for the continuous rating of the SVC and will be allowed to overload for the dynamic swings.

C. The SVC shall regulate the 220kV bus voltage to a reference voltage continuously variable from 0.90pu to 1.05pu. Normal reference point of the SVC will be 0.95pu. This value is compatible with the area generation and bus voltage requirements.

D. The SVC shall be capable of operation in both MVAR and voltage regulation modes. Normal operation is expected to be voltage regulation. Slope of the SVC regulation system shall be continuously adjustable, or adjustable in steps not to exceed 0.5%, from 0% to 5% over the full continuously variable range of the SVC.

E. The Contractor shall specify the temporary overvoltage capability of the proposed design and design the SVC control to allow safe use of the temporary capability. SVC operating time in the temporary overvoltage region shall be specified by the Contractor. If the Contractor’s design has additional short time (0.05s to 1 second) overvoltage capability this capability shall also be specified by the Contractor.

F. The SVC shall continue to generate capacitive reactive power during temporary undervoltage down to its lowest operating limit (to be specified by the Contractor). The Contractor shall specify the temporary undervoltage capability of the SVC design.

G. If SVC compensation must be shutdown due to system undervoltage conditions that persist longer than the SVC can safely continue compensation, the SVC shall automatically restart and resume compensation as quickly as possible following system voltage recovery above its continuous under voltage operating limit. The vendor shall specify the time required to restart the SVC compensation following a shutdown due to system undervoltage. The control shall have provisions to enable and disable the automatic restart feature both locally and remotely via the Employer’s SCADA system.

H. The SVC shall continue to generate inductive reactive power for temporary overvoltages up to the Contractor specified overvoltage limit.

I. All SVC and filter bank components shall be rated to withstand the continuous and short-term system operation, including harmonics specified in the Power System Characteristics section of this specification and to withstand or be protected against voltage and currents stresses that exceed these characteristics.

J. The SVC transformer and all connected equipment shall be undamaged by any internal fault no matter what fault strength is available at the 220kV high voltage SVC bus connection. Owner reserves the right to perform a 220kV staged single line to ground staged fault test and a line to line low voltage staged fault test.

3.2.3 SVC Control Concepts

The SVC shall be designed to regulate the 220kV Kandahar East bus voltage over a range of 0.90pu to 1.05pu. Normal operation will be to regulate the voltage to 0.95pu. The present application does not require power system swing damping from the SVC. However, damping capability shall be provided and activated, if necessary, to mitigate any unstabilizing effects of the fast SVC voltage regulator or other system conditions that may develop. Damping control shall have its parameters and activation adjustable by the user. Capability shall be provided for both local and remote adjustment of the regulator set points and control parameters. The control system shall be self-diagnosing for any circuit failures. The printed circuit cards shall have built-in test points and indicating lights to facilitate testing and maintenance.

A. Reference Voltage and Range of Control: The SVC shall be designed to regulate the voltage on the 220kV bus over a range of 0.90pu to 1.05pu. The reference voltage shall be continuously adjustable over this range.

B. Slope: The slope (ratio of per unit reference bus voltage change to SVC per unit current change) over the linearly controlled range of the SVC shall be continuously adjustable from 0% to 5% in no greater than 0.5% steps on the nominal 220kV system.

C. Control Accuracy: Maximum error in the controlled bus voltage provided by the SVC shall be +/- 1.0% of the theoretical value as calculated from the control reference voltage and slope settings at any possible operating point within the SVC operating range. This tolerance includes any error due to the 220kV voltage sensing transformers or other hardware.

D. Response Time: Response time is defined as the time required for the SVC to reach 90% of its final output level, in closed loop response to a step change in the 220kV system voltage reference. Desired SVC response time is 30 ms or less. Maximum overshoot shall not exceed 10% of the ordered change and the settling time shall not exceed 200ms, after which the system voltage shall be within 5% of the ordered value.

E. The Contractor shall specify the SVC response time which can be achieved between any two operating points within the SVC operating range, including fully capacitive to fully inductive, or vice versa, at the 220kV bus system impedances specified in the System Electrical Characteristics section of the specification. This shall be specified for a SVC slope of 0% and 5%. This closed loop response shall be continuously available and repeatable. Capability to adjust the response time is required. Response time adjustments shall not affect the slope characteristic of the SVC.

F. Control Power Supply: The Contractor shall provide a primary station service source, either from the 220kV bus or the SVC secondary bus. The Contractor shall also provide one source of back-up service power to the SVC for use as needed in the event of the loss of the primary station service power. In the event of the loss of both AC power sources, the SVC shall transfer to a Contractor provided source of DC power capable of supplying the control system during the time required for a safe and orderly shut down of the SVC system. In the event of an emergency SVC shut down, the SVC shall restart active compensation as quickly as possible after the system voltage recovers above the minimum SVC continuous operating voltage. The vendor shall specify the time required to restart the SVC compensation following an emergency shut down.

G. Valve Control: The gating scheme shall be designed to:

- be immune to severe harmonic distortion of the voltage waveform
- continue to operate during and following large voltage excursions
- continue to operate during and following large frequency excursions
- minimize generation of characteristic, non-characteristic and non-integer harmonics

- be immune to misoperation when the 220kV bus voltage amplitude and/or phase changes quickly (for example during system fault initiation and clearing)

3.2.4 Capacitor Bank and Reactor Control

The dynamic portion of the SVC control shall rapidly (30ms or less) regulate the 220kV bus voltage.

A. Step Size: Capacitor switching steps sizes shall be designed to minimize voltage step changes upon capacitor switching when the system is weak and the dynamic portion of the SVC is out of service.

B. The SVC control shall be capable of operating the mechanically switched reactors (MSRs) in the Kandahar East Substation to allow the SVC to operate near the zero output point. Control of MSR banks shall be made directly from the SVC control system and the MSR bank status (open, closed, manual, automatic, local) shall be reported to the SVC controller. The reactors shall also be capable of manual control remotely via the Employer's SCADA system or by operators within the station.

3.2.5 Insulation Coordination

The Contractor shall perform studies to determine that the SVC system is adequately protected against high frequency transient and dynamic overvoltages and system interactions. The Contractor shall be responsible for the insulation coordination of all equipment within his scope of supply and shall furnish all necessary protection for the supplied equipment. Protection equipment shall include surge arresters, special control features and other forms of protection according to the contractors design. Backup protection shall be provided for overvoltages that could occur due to credible failures or malfunctions of the SVC.

Contractor study reports shall document protection methods and show that insulation coordination of the SVC is adequate and that all Contractor supplied equipment is capable of withstanding steady state, dynamic and transient overvoltages to which it may be subjected. Overvoltages may be due to the SVC system, its component switching, normal SVC operation and abnormal SVC operation.

3.2.6 Availability and Reliability

A. General: The Contractor shall provide, with the proposal, availability calculations for the base bid and all proposed options including all component failure rates.

B. Required Availability: The annual availability required of the SVC shall be 98.0%. Failure or outages required for maintenance of auxiliary equipment and all other parts of the SVC, including main step-up transformer, shall be included in the determination of availability. The Contractor shall design and furnish equipment with the design objective of producing a system, that will meet or exceed stated guaranteed availability performance based on loss of capacity or the failure of equipment within his contract responsibility as measured at the 220kV bus connection point.

C. Definitions

1. **Forced outages** are outages caused by the SVC equipment which result in loss of part or all of the essential function of the SVC. These outages may be initiated by failure of components, the operation of protective devices, alarms or by manual action.

2. **Scheduled outages** are outages necessary for preventive maintenance to assure continued and reliable operation of the SVC.

3. **Outage duration** is the elapsed time from the instant the SVC is out of service to the instant it is returned to service. If the SVC is available for service such time will not be included in the outage duration, should the Employer elect not to return the equipment to service. The following shall be included in outage duration:

   - The time required to determine the cause of an outage or to determine which equipment or units of equipment must be repaired or replaced.

   - The time required by system operators/technicians for disconnection and grounding of equipment in preparation for repair work, and for removal of grounds and reconnection of equipment after repairs are complete.

   - Delays caused by unavailability of qualified Employer's personnel shall be excluded from the outage duration.

4. **Partial Outage:** If partial SVC output is available, the duration of equivalent outage shall be calculated as the product of the derated condition duration and the proportion of the nominal output range which cannot be achieved during this period.

5. **Annual Availability:** The annual equivalent availability for the combination of scheduled and forced outages in % is defined as:

$$\left[1-\sum\frac{\text{Duration of equivalent outage}}{8760}\right]*100$$

6. **Required Availability:** The annual equivalent availability for all outages (combined scheduled and forced outages) for the SVC shall be at least 98.0%. There shall be less than three forced outages of the SVC per year.

3.2.7 Interference

A. Broadband Interference: The Contractor shall take necessary precautionary measures to insure that there will be no misoperation, damage or danger to any equipment or system due to broadband interference and effects. The broadband interference includes: Power Line Carrier; radio and television; microwave; and wireless communications.

B. Compliance and Measurements: The Contractor shall perform ambient (before construction) and after commissioning measurements to document actual noise levels for the above types of communication and frequency bands used in the vicinity. Measurements taken after the SVC is placed into service shall include all operating modes and levels that will cause worst-case interference conditions. Based on these two different measurements, SVC system contribution and compliance will be determined. The measurement results and conclusions will be provided to the Employer.

3.2.8 Audible Noise

A. The maximum sound level generated from the SVC system and any associated equipment, including the main transformer, supplied by the Contractor under any output level within the SVC's operating range combined with the audible noise from the existing substation equipment shall not exceed sound levels allowed by local regulations at any point on the substation property line. This shall be measured on the “A” weighted scale. The ambient noise level inside the SVC control room shall not exceed 50dBA.

B. The Contractor shall make ambient audible noise level measurements before and after SVC installation to verify compliance with this requirement. Any noncompliance shall be corrected by the Contractor to the Employer’s satisfaction. The Contractor shall make these corrections at no cost to the Employer

3.2.9 Harmonics

The studies shall document acceptable filter performance for various system configurations and be supplied prior to SVC installation. Harmonic studies shall evaluate the maximum harmonic levels at the point of common coupling (PCC). In addition, these studies shall be used to demonstrate that the AC filters do not cause any resonance with the rest of the power system and that harmonic distortion limits can be met by the filters designed by the Contractor. Resonance problems related to the SVC filters, capacitor banks, and system impedances shall be avoided for all credible system conditions. The Contractor shall be required to meet IEEE 519 harmonics requirements at the PCC (the 220 kV substation bus) with all equipment installed. Harmonic performance and filter design shall consider characteristic, non-characteristic and non-integer harmonics from the 2nd to the 50th or higher if necessary. Actual compliance shall be based on field measurements performed by the Contractor after commissioning at all operating modes and output levels that may cause worst-case harmonic distortion.

- The following limits shall be applied:
  - Individual harmonic voltage distortion (D_n) (24 hr. Average) — 1.5%
  - Total harmonic voltage distortion factor, THD (24 hr. Average) — 2.5%
  - Telephone influence factor (TIF) — 50
  - I*T product — 10,000
- Harmonic Definitions:
  - Voltage distortion factor, $D_n = (E_n/E_l)*100$
    E_l = rated line-to-ground system voltage (rms)
    E_n = Line-to-ground voltage of the nth harmonic (rms)
  - Total harmonic voltage distortion, $THD = (100 / E_l)*\sqrt{\sum E_n^2}$
    Summation from harmonic n = 2 to 50
  - Telephone influence factor, $TIF = (1/ E_l)* \sqrt{\sum (E_{n*}W_f)^2}$
    Summation from n = 2 to 50
    W_f = weighting factor for nth harmonic (see IEEE Std. 519-1992)
  - I*T Product: $I*T = \sqrt{\sum (I_n* W_f)^2}$
    Summation from harmonic n = 2 to 50
    I_n = nth harmonic current injected into the system (rms)
- In meeting these requirements the design of the SVC shall take into account mistuning, failed power electronics, component tolerances due to manufacturing and temperature deviations

in transformers, reactors, and capacitors, normal system frequency, SVC operating with redundant valves out of service, and component aging.

- The SVC components shall be designed to carry the harmonic currents caused by the background harmonic distortion of the system as well as those produced by the SVC itself. The harmonic currents from the system and the SVC shall be added quadratically. At least a 20% safety margin shall be applied.

3.2.10 General

The Contractor shall guarantee that the total electrical losses for the SVC will not exceed those stated by the Contractor. The guaranteed total electrical losses stated will be used for evaluation of bids. If the guaranteed total station losses are exceeded, a corresponding penalty will be applied.

The guaranteed losses shall include all equipment within the Contractor's scope of supply, including building heating/cooling losses. Any filter loss shall be included. Where possible, the Contractor shall determine the electrical losses and power requirements of equipment by direct measurements. Calculated values provided by the Contractor may be used where direct measurement of losses and power requirements is not feasible.

For the purposes of calculating losses, it shall be assumed that the ambient temperature is 30^{o}C, the Kandahar East Substation bus is at 0.95pu and the slope setting is 3.0%. System auxiliary power requirements shall be based upon the total electrical power required by auxiliaries from the station service source.

3.2.11 Loss Evaluation

It is expected that the SVC will be operating near 0 Mvar the majority of the time. The losses for the SVC shall be given at the operating points defined below, and these losses will be used in computing the evaluated cost for the SVC. In addition, the Contractor shall provide a curve for the total operating losses over the entire steady state operating range of the SVC.

Operating Point #1	+10 MVAr	Weighting Factor: 0.1
Operating Point #1	0 MVAr	Weighting Factor: 0.6
Operating Point #2:	-10 MVAr	Weighting Factor: 0.3

The losses at each operating point will be multiplied by the associated weighting factor. The weighting factor is the approximate expected time of operation at a particular operating point. These losses will then be totaled and economically assessed using the value from WO-LT-0048 Section 2.4.2.3

Should the actual total losses as determined by testing and calculation, where appropriate, exceed the guaranteed losses, the Contractor shall pay to the Employer an amount determined by the actual losses in excess of the guaranteed losses multiplied by the value stated elsewhere in these specifications.

NO CREDIT WILL BE GIVEN FOR ACTUAL LOSSES WHICH ARE LESS THAN THE GUARANTEED LOSSES.

3.3 Equipment Specifications and Design Requirements

3.3.1 General Requirements

All equipment manufactured or purchased for this contract shall be in general conformance to these specifications. The equipment specifications are intended to describe the desired features of each piece of equipment, but are not intended to limit the manufacturer’s design to provide the best facility.

3.3.2 Transformers

3.3.2.1 General

The Contractor shall state in the proposal the proposed transformer manufacturer and the actual location of manufacture of the unit(s) that will be supplied under this contract. The Employer will review and approve the proposed transformer and manufacturing location.

Refer to WO-LT-0048 Section 2.4 for detailed transformer specifications.

Due to the location of the site, it is desired to use single phase transformers with a 4th single phase transformer as a spare. The station shall be designed to allow efficient replacement of a failed transformer with the spare transformer as quickly as possible, without moving the transformer and, with the exception of jumpers to the transformer bushings, no addition or modification of bus work.

The transformer shall be designed to withstand the stress of all operating modes and system conditions as specified, including negative sequence currents and harmonics.

3.3.2.2 Losses

Losses are to be guaranteed and will be evaluated along with the complete SVC facility.

3.3.2.3 Maintenance Considerations

The recommendation for spare parts shall be included in the instruction book for the original equipment. This recommendation must include all spare parts that the Manufacturer recommends be carried in stock for these transformers plus all gaskets and other expendable items that may be reasonably required during the preliminary operating and adjusting period that always precedes normal operation.

3.3.3 High Power Semiconductor Devices

3.3.3.1 General

The high power semiconductor devices (valves) and all necessary accessories shall be designed to ensure satisfactory operation according to the overall performance requirements and to meet the specified reliability. The proposed valves shall be of a type in, or ready for, commercial production with fully proven characteristics. The Contractor shall state in the proposal significant departures from previous designs of valves in service in similar applications.

Any plastic components shall be of a type that is not degraded by corona discharges.

The valves, and all related components, shall be designed to withstand the stresses associated with steady state operation, transient operation and overload conditions as implied by this application. The Contractor shall be responsible to demonstrate that all relevant aspects of overvoltage and overcurrent stresses have been taken into account, including those due to malfunctions in the valves' firing system and faults occurring in various parts of the AC system.

3.3.3.2 Maintenance

The valve arrangements shall be designed to permit easy access for visual inspection, routine maintenance, removal, replacement, and handling of the valve modules or components. Such work shall result in minimal loss of coolant and the Contractor shall provide means of retaining any coolant lost. It shall be possible to carry out replacement of one module or component within 2 hours from shutdown to startup, excluding time for switching procedures, but including the time required for identification of the faulty module or component.

A continuous monitoring system shall be provided to detect failed valves and provide indication of each failure and its location within the valve assembly. This indication shall be made available in the control room. Contacts shall be provided for connection to a sequence of events recorder and a supervisory control status point so that valve failure events can be logged. The monitoring system shall be of fail-safe design such that failure of the monitoring system will be detected or appear as a valve failure.

The Contractor shall provide one complete set of tools and lifting and access equipment for valve maintenance.

3.3.3.3 Redundancy

The valve design shall be such that the SVC will continue to operate at full capacity with the loss of any one component. All performance and protection functions shall be met with any one failed component out of service. The Contractor shall be aware of the availability requirements when designing redundancy and maintenance procedures.

3.3.3.4 Guaranteed Failure Rate

The Contractor shall state the guaranteed failure rate of high power semiconductor devices. Device failures shall include those caused by a malfunction of the firing system and of all auxiliary components associated with such high power semiconductor devices. The failure rate of devices will be monitored by the Employer. The annual guaranteed failure rate of the devices shall be calculated for a one-year period and shall not include failures directly attributable to operating and maintenance error.

If the actual failure rate exceeds the guaranteed failure rate, the Contractor shall supply the actual number of components equal to the difference between the actual failure rate and the guaranteed failure rate over a 20-year period.

The Contractor shall agree to furnish new devices on a schedule determined by the Employer that will allow use of the devices prior to exceeding the device shelf life.

3.3.3.5 Valve Protection

The Contractor shall provide adequate overvoltage and overcurrent protection of the valves. The Contractor shall state in the proposal the methods of overvoltage and overcurrent protection of the valves and the levels at which these protections operate.

Valves shall be provided with means for individual emergency firing in the event of an overvoltage or failure of firing pulses to one or more individual valves.

The SVC shall be automatically disconnected whenever the number of failed valves and associated electronics is more than the number of redundant valves.

The valve shall be protected against overcurrents (temperature). Emergency tripping of valves shall take into account pre-trip overcurrent magnitude and duration as well as decay of trapped charge in other components.

3.3.3.6 Testing

Factory tests on the valves shall be performed by the Contractor. The Contractor shall submit a detailed test program and test specification, including type tests and routine tests. All test circuits shall be such as to adequately test performance under realistic worst case stress conditions and shall demonstrate in a simple and conclusive manner the capability of the valve. All tests shall be in accordance with the applicable IEC and IEEE standards.

3.3.3.7 Valve Cooling System

The purpose of the valve cooling system is to remove the heat produced by the valve operation and transfer this heat to the outside ambient air. The cooling system shall be furnished complete with all necessary equipment and facilities, including, but not limited to, interconnecting piping, ductwork, circulating pumps, blowers, heaters, make-up reservoirs, heat exchangers, filters, water treatment plant, instrumentation, automatic controls, alarms and control power.

The cooling system shall be designed such that the failure of any single component will allow the SVC to continue to operate at full capacity. Single piping and tubing is acceptable provided the materials are stainless steel and all joints and gaskets are designed for high reliability. A single non-metallic piping manifold at the valve structure may be used.

The cooling circuit shall provide full heat rejection and may be a closed loop de-ionized water recirculating system. Each loop and each branch shall have manual valves to allow draining for maintenance and isolate it from the rest of the system without disrupting the operating loop. The cooling system shall be designed to allow the SVC to maintain full capacity at the maximum ambient temperature and maximum reactive power output and shall be able to operate at the lowest ambient temperature with the SVC off-line.

Replacement or maintenance of cooling system components shall be possible without shutting down the system. If redundant pumps are provided, the cooling system shall be designed to cycle the pumps periodically.

The high purity (high resistivity) water in the primary closed loop system shall be circulated through the heat producing electrical equipment at a constant flow rate. A purifying loop to maintain the high purity in the closed system shall be provided. The Contractor shall specify the design resistivity of the system and shall describe the proposed methods of detecting and responding to abnormal conditions.

The quantity of de-ionizing material shall be sufficient for continuous operation for a period longer than the Contractor specified maintenance interval without replacement. De-ionizing materials shall be replaceable without shutting down the cooling system.

Provision for make-up water shall be provided by the Contractor. The system shall be designed so that the addition of make-up water shall not be required for a period longer than the Contractor specified maintenance interval. There is no domestic water available on site. Contractor shall provide adequate make-up water storage and any required treatment facilities required by the facility design and maintenance interval.

The secondary cooling circuit shall be a closed system using a water/glycol mixture to prevent freezing in the event of loss of station power. The heat transfer from the primary to secondary cooling circuits shall take place in a liquid-to-liquid heat exchanger. Such heat exchanger shall be of double wall construction to assure that the liquids in the primary and secondary systems do not mix.

No discharge of the primary or secondary loop cooling system water will be allowed. The heat transfer from the closed water system to the ambient air shall take place in a liquid to air heat exchanger.

Alternative Liquid Cooling: As an alternative, the Bidder may propose a single loop, water/glycol mixture cooling system for the valves. The Bidder must then provide a full detail of the cooling system and point out its cost and operational benefits over the primary/secondary water cooling system outlined above. This method of cooling may be preferred if it provides maintenance and operational advantages.

3.3.4 Instrument Transformers

3.3.4.1 General

The Contractor shall supply all voltage and current transformers necessary for control, protection and monitoring of the SVC and shunt/filter capacitor banks. The Contractor shall ensure that the accuracy, ratings and performance of all instrument transformers are adequate for its specific purpose.

Instrument transformers shall be designed, manufactured and tested according to applicable IEC standards. The Contractor shall provide the description, rating, performance, dimension and proposed tests for all instrument transformers provided.

3.3.4.2 Voltage Transformers

The voltage transformers shall be designed to avoid saturation at voltages up to at least 1.2pu continuous and 2.3pu for 1 cycle. Further, no ferroresonance conditions shall occur between voltage transformers and capacitors including stray capacitances.

Only inductive type voltage transformers are acceptable.

3.3.4.3 Current Transformers

The current transformers shall be provided with the appropriate number of windings as required by the Contractor’s design. Each winding of the current transformer shall be provided with an individual core.

The current transformers shall be capable of withstanding, with the secondary short circuited, a fully offset primary current having an AC component with an rms value equal to the maximum fault levels specified.

3.3.5 Filters and Shunt Capacitors

3.3.5.1 General

Shunt capacitor banks shall be provided as required by this specification for harmonic filter requirements and SVC rating.

The capacitor banks shall be furnished complete with all racks, insulators, buswork, structures, grounding, instrument transformers, capacitor unit failure detection, and protection. The capacitor banks shall be mounted in racks of horizontally mounted capacitors ready for vertical mounting of the racks and any other equipment. Capacitors shall not be shipped mounted in racks. The capacitors shall be mounted to allow safe access to the capacitor/filter area with the equipment energized or fenced and equipped with appropriate interlocks to prevent access until safely disconnected and grounded.

The capacitor banks shall be equipped with discharge devices as required to allow rapid restoration into service. The capacitors shall be designed, rated, and tested in accordance with the latest issue of applicable IEC standards.

3.3.5.2 Capacitor Units

The individual capacitor units shall be of the all-film polypropylene dielectric type, in single bushing cases. The minimum sustained overvoltage rating shall be 120% of nominal voltage. The measured capacitance shall be stamped on the nameplate of each can.

The cases shall be designed to allow for expansion and contraction due to all ambient and loading conditions expected during the life of the unit, including short-term transient conditions. The capacitor design shall be such that it prevents rupture of the case.

The dielectric fluid used within the capacitor unit shall be environmentally safe and biodegradable. The capacitor units shall be completely impregnated with the dielectric fluid.

Capacitor units shall be internally fused. Fuseless designs are not acceptable.

3.3.5.3 Capacitor Banks

Stacks shall be supplied complete with all auxiliary equipment and material necessary for a complete installation in the field, including all insulators capacitor units, and the neutral bus between the stacks.

Elevating structures shall be furnished complete with all necessary bracings and grounding pads. The structures and racks shall be aluminum or galvanized steel, pre-drilled with all suitable fasteners. All structural members shall be electrically connected to each other in order to ensure adequate grounding of the rack during maintenance and shall be connected to the ground mat. Steel rack components shall not be used as an electrical bus.

Provisions for mounting potential transformers and/or neutral current transformers shall be furnished with the structure. All bolted aluminum connections shall be flat washers with locknuts. Racks shall be furnished with lifting eyes for handling. Red warning signs shall be attached to all sides of all racks reading “WARNING - ENERGIZED FRAMES. Each rack shall be labeled with the maximum and minimum capacitor unit capacitances which may be substituted as spares.

The capacitor banks shall be designed, configured, and spaced so that each individual capacitor bank can be serviced, including the identification and changing of failed units, without requiring the adjacent banks to be taken out of service.

3.3.5.4 Testing

Capacitor banks shall be tested according to applicable IEC standards. All the necessary tests to assure adequate electrical, thermal and mechanical capabilities shall be performed. The Contractor shall submit for review by the Employer, a detailed program of design and production tests to be performed on the capacitors. The Contractor shall specify the value and tolerances for tests to be performed.

3.3.6 Switching and Interrupting Devices

3.3.6.1 General

As required by the design, the Contractor shall provide switching and interrupting devices to control and protect the SVC equipment. Switching and interrupting devices furnished under these specifications shall be in accordance with all the requirements of applicable IEC standards, and shall be designed to operate under the conditions listed in this specification.

The switching and interrupting devices shall be properly rated for capacitor switching and fault interruption duty where used on filter or switched capacitor banks. All switching and interrupting devices shall be furnished in accordance with the material supply portions of the specification.

3.3.7 Station Service

3.3.7.1 General

The Contractor shall furnish all required AC and DC distribution systems to supply all loads in the SVC facility. The primary AC station service source will come from the adjacent Kandahar East Substation. The Contractor shall provide all duct banks, cabling and pull boxes required to connect the Contractor furnished station service transformers and secondary equipment.

The auxiliaries shall be capable of riding through all frequency and voltage conditions as specified in Section 3.2 without loss of SVC capacity or shutdown of auxiliary systems. The Contractor shall provide all protective relays or other systems required for protection of the station service system and shall be responsible for coordination of all such protection.

3.3.7.2 Back-up Source

The SVC, including auxiliaries, will be required to operate under the conditions set forth in Section 3.2 of these specifications. The SVC will be required to be capable of operating in the event of the loss of the primary station service source. In addition, the SVC will be required to shut down in a safe and orderly manner in the event of the loss of all station service sources. The Contractor shall provide for a back-up station service source sized to allow full operation of the SVC. This may be a source from the low voltage side of the SVC step-up transformer or back-up generator at the Contractor’s option.

If required for emergency operation or orderly shut down, the Contractor shall provide a back-up station service source such as uninterruptible power source (UPS) or generator. Such system shall be designed to meet the requirements of emergency operation of safe shutdown with the back-up system at 85% of rated capacity.

3.3.7.3 Automatic Transfer Equipment

The Contractor shall provide automatic transfer equipment for the SVC AC station service to switch to the secondary power source in the event of primary source failure. The equipment shall switch back to the primary source upon restoration of the primary source.

3.3.7.4 DC Power System

If required for the Contractor’s design, station battery systems shall be compatible with and of the same type as the battery systems in the Kandahar East Substation and shall include a battery charging system.

The battery shall consist of cells of proven technology designed for the type of service required. For the purposes of this specification, proven technology shall be defined as cells that have been in successful commercial service in similar type applications for a period of time sufficient to establish a service life and maintenance history.

3.4 Controls, Metering, Instrumentation and Protection

3.4.1 Control Requirements

The SVC control system shall be designed to provide for automatic, unattended operation of the facility. However, the control system design also shall provide for local manual operation and remote operation of the SVC from the Employer's SCADA system. The SVC shall include provisions for an orderly and safe shutdown, even in the absence of utility power.

An HMI shall be provided in the SVC building for local control and troubleshooting. Control shall also be provided through a SCADA HMI located in the substation control building. The SCADA HMI shall be provided with fully functioned control and monitoring capability for the SVC.

An OPGW fiber communications system with connectivity back to the NLCC (National Load Control Center in Kabul) will be commissioned at some point after the SVC is in service. The Contractor shall provide commissioning assistance via remote data link to ensure proper communications between the control and the Employers SCADA system control center at the time the OPGW fiber is commissioned. The Contractor shall provide physical interconnection with the SCADA RTU for future connectivity with the NLCC.

One purpose of the SVC is to assist the Employer in responding to abnormal utility system conditions. Therefore, the Contractor shall design the control system, including its power supplies and connections to sensors, to be immune from utility voltage and/or frequency excursions, transients and similar events. The control system shall meet or exceed the surge withstand capability requirements of applicable IEC standards.

The control system shall provide for setting the operating mode and changing set points from a SVC operator console and by signals from the Employer's SCADA system. Initiation and continued operation in any of the modes shall be as allowed by the set operating state.

All local and remote control and monitoring system components shall be housed in a separate control room in the SVC building. The control system components shall be housed in freestanding, indoor metal-clad cabinets. The equipment shall be designed to operate properly at the maximum allowable temperature and humidity determined by the building HVAC design. Supplemental cooling for the control room may be provided if necessary.

The control system shall be of digital design. The design shall be such as to prevent externally supplied, control panel or local signals from causing the SVC to operate in an unsafe manner or in a manner that may damage the SVC, its equipment, or the connected utility system equipment.

The SVC control shall include, as a minimum, the states and operating modes as outlined below.

3.4.1.1 Shutdown

The shutdown state shall be defined as 220kV circuit breaker(s) open; non-critical power supplies de-energized; control system power may remain energized. This mode includes both normal shutdown and system trips requiring reset.

The control system shall initiate shutdown under the following conditions and remain in the shutdown state until a reset signal, either local or remote, is initiated:

- Emergency shutdown operation

- Loss of station service (Simultaneous loss of both sources)
- Loss of cooling system
- 220kV circuit breaker trips that isolate the SVC
- Door interlock - initiate shutdown when the door to the valve room is opened. A "defeat" feature shall allow for maintenance. Interlocks shall be self-resetting.
- Smoke/fire alarm
- Fire Suppression operation
- Control logic trouble
- Failure to restart from disconnect state after automatic restart attempts
- Remote disable (no reset required)

3.4.1.2 Disconnect

The disconnect state shall be defined as 220kV circuit breaker(s) open; non-critical power supplies and control system power energized.

Some faults or failures are expected to be transient in nature. Normal faults should be cleared in about six (6) cycles by primary protection or 35 cycles by back-up protection. The SVC shall stay on line for these cases. The control system shall open protective devices upon fault occurrence and shall attempt to automatically start-up after a Contractor specified adjustable time delay without requiring a manual reset. The control system shall go to the disconnect state under the following conditions:

- Synchronization Error – The SVC is unable to synchronize with the utility grid.
- Grid transient conditions (i.e., line switching or reclosure action)
- Utility voltage out of emergency operating range for a length of time as defined in this specification.
- Utility line frequency out of emergency operating range as defined in this specification (field adjustable in 0.1 Hertz increments)
- Over-temperature on the SVC equipment, controls or other equipment.

3.4.1.3 Operate

The Operate state shall be defined as all circuit breakers closed and reactive power available to flow to or from the SVC and transformer system to the utility system. Normal operation shall include all operating scenarios as described herein. It also may include additional modes and sequences deemed necessary by the Contractor. The SVC is operating normally and automatically, with no faults detected or alarms.

3.4.2 Operator Interface

The Contractor shall provide all the operator control, indication, alarm, and metering functions that are necessary for operating the SVC, either locally from the operator console in the SVC control room or remotely through supervisory control. The Contractor shall provide an interface to the Employer's SCADA system master station.

3.4.2.1 Local Control

Local control of the functions and set points for the SVC shall be accomplished through an operator interface console located in the SVC control room. The operator console shall be equipped with a minimum of a 19-inch color LCD type monitor and a read/write compact disk/DVD drive. The PC for the operator interface shall be server quality and shall be equipped with redundant power supplies and hard disk drives. The Contractor shall provide remote access from Contractor's manufacturing offices to the operator interface to facilitate remote trouble shooting by factory personnel. Such remote access shall be coordinated with the Employer to address security concerns.

The operator console shall be designed so that alarms shall not be able to be deleted while they are active. The audible alarm signal shall be able to be silenced with a single keystroke or mouse click, but shall reset itself with the addition of a new alarm. The audible alarm shall have the capability of being defeated from the local control, as the site will be primarily unmanned. The operator shall be able to call up an alarm summary display with a single keystroke. The display shall enter the newest alarms at the top and if the display is full, delete the oldest alarms. The system shall log all alarms, control actions, and system abnormalities to a hard disk and shall send all alarms and other activities directly to a local log printer furnished by the Contractor. The system shall have the capability to enable and disable the local printer from the local control console.

All control commands shall be of a select before operate (SBO) format. First, the component to be operated is selected then a clear selection of the control function to be performed is chosen (i.e. close or open) with "operate" and "cancel" commands. The state indication shall be shown with logical signs. The color of each equipment or function shall show the state of the equipment or function. Colors shall be designed to comply with the Employer's standard color scheme. Information on the standard color scheme will be provided to the successful Contractor. The intermediate position or missing position of equipment such as motor-operated switches shall also be presented clearly.

The SVC shall include a local control panel or console within the SVC building. The local control panel may consist of manual control switches, or, if fully redundant, may utilize control actions initiated by digital signals through a local control console. Emergency trip push buttons shall be manually operated and not require action from the digital control, as described elsewhere in these specifications. As a minimum, the following operator controls shall be located on the local control panel:

- Trip/close for the 220kV circuit breaker(s) connected to the main step-up transformer.
- SVC Start/Stop
- Reset toggle or push-button. When reset is initiated, the control system shall resume control and proceed to the appropriate operating mode
- Reset cut-out selector switch to disable remote or local reset signals
- A selector switch to manually set the operating state (i.e., shutdown, disconnect and operate) and to have the control systems set the operating state automatically

- A selector switch to manually set the operating mode and to have the control system set the operating mode automatically

- An emergency trip pushbutton shall be located near the control panel and be suitably protected to prevent accidental operation. Operation shall be as described elsewhere in these specifications.

3.4.2.2 Supervisory Control

The SVC will be controlled by the Employer’s system control center. The Contractor shall furnish all necessary equipment and functions to facilitate control from a remote location. The SVC control shall have the equipment and capability to communicate directly with the Employer’s SCADA system master station using a protocol compatible with the Employer’s SCADA system. All functions necessary to operate and monitor the SVC remotely will be available via the communications link. The Contractor shall ensure complete compatibility with the Employer’s master station communications system.

The Contractor may provide remote control through a Contractor supplied RTU (Remote Terminal Unit). The RTU shall be interfaced to the SVC control using standard dry contacts and digital inputs/outputs or Employer approved digital protocols. All functions necessary to operate and monitor the SVC remotely will be interfaced into the Contractor supplied RTU.

The Contractor shall provide a master supervisory/local control selector switch to be located on the SVC control enclosure or RTU. This switch shall disable all remote control functions, but shall not disable remote instrumentation, status and alarms functions. The control circuits shall be arranged to ensure that when the selector switch is in the “supervisory” position, the associated controls on the operator control console in the SVC control room shall not be capable of affecting the device or function. Similarly, when the selector switch is in the “local” position, the associated remote controls shall not be capable of affecting the device or function.

3.4.2.3 SCADA RTU

If required by the Contractor’s design, a SCADA RTU will be provided by the Contractor that complies with the Employer’s specifications for the monitoring and control of all equipment normally used for such control and monitoring by a power dispatch center. The RTU shall simultaneously communicate with the Employer’s SCADA system and the local control system in the SVC control room via a communications link compatible with the Employer’s SCADA system.

3.4.3 Monitoring and Instrumentation Requirements

The control equipment shall contain monitoring functions needed for safe and reliable operation of the SVC. All protective functions and diagnostic monitoring shall be included. Two levels of alarm signals, namely warning and shutdown, shall be incorporated. Each alarm shall be annunciated to the SVC control, logged by an events printer and annunciated remotely via SCADA.

3.4.3.1 Station Alarm System

The alarm and event system shall be capable of continuous monitoring of all points simultaneously and shall have a resolution of better than 10 ms. The alarms and events shall be presented in chronological order with the status of the alarm shown in different color or text. The alarms shall be connected and synchronized to a GPS clock.

Each alarm on the system shall be categorized into levels of criticality such as critical and non-critical. Alarm processing shall be provided to filter system events on specific screens to ensure the operator is notified of primary events and is not inundated with lower level events which were created by other primary events. Each lower level alarm shall have the capability of being automatically upgraded to a critical alarm after a specified delay. A tabular screen shall be provided that lists a summary of all abnormal alarms.

A continuous monitoring system shall be provided to detect failures in the high power semiconductor devices and provide indication of each failure and its location within the valve. This indication shall be made available in the SVC control room. Indication shall also be made to a sequence of events recorder and a supervisory control status point so that valve failure events can be logged. The monitoring system shall be of fail-safe design such that failure of the monitoring system will be detected and appear as a valve monitor failure.

A complete monitoring system for the cooling system including warning, trouble, leaks and shutdown alarms shall be furnished. All warning alarms shall be annunciated on the SCADA system. Separate sensing devices (flow indicators, pressure switches, etc.) shall be used for SCADA indication and local indication.

The Contractor shall provide, at a minimum individual alarms and/or status change reports for the following types of events. It is possible that multiple levels of some alarms may be necessary to indicate warning and critical levels.

- Operation of any main and backup protection circuits
- Operation of control limits
- Operation of local/supervisory switch
- Operation of automatic/manual switch
- Loss of redundant equipment, including controls or operator interface
- Change in status of circuit breakers
- Circuit breaker trouble alarms
- Transformer trouble alarms
- Building door(s) and/or gate open
- AC & DC station service supply failure
- Cooling system fan or pump failure
- Cooling system trouble as specified in Section 3.3
- Capacitor unit failure
- Depleted demineralizer (de-ionizing) cell
- Low water resistivity
- Low water tank level
- Abnormal water or air flow

- High coolant or exhaust temperature
- High differential pressure across filter
- Relay or protection failure
- Loss of cooling system rated capacity
- Loss of synchronism with system voltage
- Excessive number of capacitor unit failures
- Excessive overcurrent in the high power semiconductor devices
- High power semiconductor device failure
- Fire detection/suppression system status and trouble alarms
- Battery charger trouble
- Battery voltage alarms
- Control PC trouble alarms
- Time synchronization status and alarms

3.4.3.2 Fault Recording System

The Contractor shall provide high speed, analog and digital fault recording of significant quantities, including but not limited to, AC and DC voltages, current harmonics to the 25th order, THD, and selected control and protection signals. The fault recording system shall be capable of communication with the Employer's control center via an Employer specified communications link. This system will be part of the communications system provided by the Contractor.

The event channels shall be designed with potential free contacts. The sampling rate shall be at least 96 samples per cycle. Each record shall include at least 0.2 seconds of pre-fault quantities and at least 1.8 seconds of post fault recording. The recorded values shall be retained in the case of a failure in the auxiliary power supply system. The fault recorder shall be synchronized with the GPS clock.

The event channels shall provide sequence of event time tags with a one-millisecond resolution and shall be time correlated to the analog portion within 1 millisecond. All time tagging shall be performed at the recorder. The output shall list the chronological sequence of occurrence of changes of state of each input, indicating the time of occurrence.

3.4.3.3 GPS Clock

The Contractor shall provide a GPS (Global Positioning Satellite) clock. The antenna shall be furnished and installed outdoors as recommended by the manufacturer. The GPS clock shall be connected to all alarm, monitoring, protection, and control system within the SVC. All time tagged alarms shall receive the time from the GPS clock. A redundant GPS clock shall be provided.

3.4.3.4 *Metering and Instrumentation*

All metering, sensors and test points in the SVC shall be easily and safely accessible for calibration, maintenance and troubleshooting by the Employer. The Contractor shall provide and install current and voltage test switches for each protective relay and for each set of metering within a CT circuit. The Contractor shall also install test switches for each protective relay input and output used.

The Contractor shall provide a complete metering system for the SVC, including any required current and voltage transformers, to measure all required parameters near the 220kV terminals of the SVC main step-up transformer.

The required SVC metering points are listed below. The metering shall have capabilities for local indication, local recording and remote supervisory indication. These are minimum requirements. The Contractor shall specify any additional metering needs.

- Total SVC MW/MVAr (reactive and capacitive)
- SVC line currents (each phase)
- Harmonic filter phase current (each phase)
- 220kV bus voltage (each phase and three phase)
- 220kV bus voltage (average)
- SVC AC bus voltage (each phase and three phase)
- Zero sequence voltage

3.4.4 Protection Requirements

The Contractor shall provide a complete protective relaying system based on prudent industry practices and local utility requirements. The protective relaying shall be integrated with the SVC control system. However, integration into the SVC control system shall not circumvent normal protective relaying functions.

All protective equipment and schemes shall be properly coordinated with the protection of the Kandahar East Substation.

The Contractor shall use microprocessor type protection equipment to the extent possible. All microprocessor relays used shall communicate to Employer’s control center via an Employer approved communications link. This system will be part of the communications system provided by the Contractor. The Contractor shall provide a communications switch specifically designed for this purpose.

As a minimum, the Contractor shall provide differential and phase and neutral overcurrent protection for the main step-up transformer. Protective devices furnished with the transformer shall be incorporated into the protection system design for the transformer.

The low side bus and cable shall be protected by differential and overcurrent relays. Capacitor protection, shall include, at a minimum, voltage unbalance protection.

3.4.5 Communications Requirements

3.4.5.1 Telephones

The Contractor shall furnish all required permanent telephone(s) and the necessary equipment to interface with the local telephone company and all other devices required for a complete voice and data telephone communications system. The telephone(s) shall be located in the area of the operator's console. The Contractor shall provide any telephone communication circuits required during construction and for Contractor's remote access to the control system and other devices.

3.4.5.2 Remote Communications

The Contractor will provide digital communications to the control room area of the SVC building. The communications shall interface to the Employer's digital communications network. The Contractor shall provide the necessary communication cable from the existing Kandahar East Substation to the SVC building. The Contractor shall be responsible for furnishing all Employer specified terminal equipment located in the SVC building. A specification on available communications and required equipment will be furnished to the successful Contractor.

The Contractor shall provide communications for remote access from the Contractor's facilities to the SVC control for the purposes of commissioning, troubleshooting and ongoing factory support. The remote access shall have full capability for all control, indication and metering to allow the Contractor to assist in troubleshooting and maintenance of the SVC after the contractor leaves the site and during the warranty period. These facilities may remain in place for the life of the SVC. The Contractor shall propose a schedule of charges for assistance after the warranty period is complete. Any remote access for the purposes of Contractor use shall be coordinated with the Employer to address security concerns.

3.5 Installation Requirements

3.5.1 Sitework

The work consists of all excavating, filling, grading, backfilling, and related items necessary to complete the site work for the SVC facility as described in Section 2.4 of WO-LT-0048.

3.5.2 Concrete

Concrete foundations shall be designed and installed in accordance with Section 2.4 of WO-LT-0048. Non-ferrous reinforcing bars shall be used in reactor foundations.

3.5.3 Steel Structures

Design, fabrication and installation of steel structures require for the SVC installation shall comply with the specification for structures contained in Section 2.4 of WO-LT-0048. Contractor shall ensure that steel structures are located in the area of influence of the reactors.

3.5.4 Buswork

General: Buswork shall include rigid buses, strain and jumper buses, cable jumper, static wires, fittings, and all hardware required to form a complete system of current-carrying paths connecting the equipment in accordance with Section 2.4 of WO-LT-0048.

3.5.5 Equipment

General: Installation of equipment shall consist of receiving, unloading, reloading (if necessary), storage, placement and field assembling of equipment in accordance with the manufacturer's installation instructions and Section 2.4 of WO-LT-0048.

3.5.6 Fencing

The fencing required to enclose the SVC shall be designed, furnished and installed in accordance with Section 2.4 of WO-LT-0048. Fencing shall be placed out of the field of influence of the reactors, or constructed with non-ferrous materials. Non-ferrous fencing materials must meet security requirements of the overall installation.

3.5.7 Grounding

A complete grounding installation for the facility shall be designed, furnished and installed, which shall conform to Section 2.4 of WO-LT-0048 and all applicable codes and shall connect to the Kandahar East Substation grounding system at intervals appropriate to the Contractor’s design.

3.5.8 Conduit and Fittings

General: Contractor shall install electrical conduit and accessories required for embedded and exposed conduit systems in accordance with Section 2.4 of WO-LT-0048.

3.5.9 Wire and Cable

General: Contractor shall furnish and install all connecting wires and cable required and shall be responsible for all attachment materials to complete the installation in accordance with Section 2.4 of WO-LT-0048.

3.6 Building Specification

3.6.1 SVC Building

The Contractor shall provide all labor, material and equipment necessary to complete the building required to house the SVC equipment and controls. The SVC building shall provide adequate space for all Contractor supplied equipment requiring indoor installation.

The control room shall house all control and protection facilities except local controls integral with the equipment or separately mounted near the corresponding equipment. The layout of equipment in the control room shall allow a minimum clearance of 1000 mm to adjacent walls and 1200 mm between rows of equipment.

Viewing windows of approximately 10,000cm^2 in size shall be provided for all areas of the facility where access is not allowed while the SVC is in operation. Such viewing windows shall be located on inside walls, preferably between the control room and such equipment. The glass used within the viewing windows shall be a laminated safety glass.

Areas where battery banks are located shall be designed in accordance with applicable IEC standards.

3.6.1.1 Design Requirements

Storage for spare part shall be coordinated with the substation control building storage area design specified in WO-LT-0048.

Building construction and materials shall be consistent with those specified in WO-LT-0048.

The building and foundation shall be designed in accordance with all applicable provisions of local building codes, as modified herein. The building and foundation shall be in accordance with the Contractor's geotechnical investigations. The building shall be designed so that ice and snow sliding off the roof will not damage any equipment or bus and will not unload onto the main entrance area.

In addition to environmental loads, the roof shall support a collateral dead load. The collateral dead load shall be determined by the Contractor considering items such as pipe supports, cable tray, etc. This load shall be included in all load cases.

Insulation shall be provided as appropriate for the structure type. Insulation shall be as required to provide minimum R-values for walls and roof as required by local codes or efficient operation of the HVAC system.

3.6.1.2 Erection

A concrete entranceway or walkway shall be provided and shall have a broom finish with tooled edges. Concrete floor slabs shall be steel troweled to a hard surface and perfectly level (unless given a specified slope), without bumps, pits, or trowel marks. A suitable hardener shall be used.

The Contractor shall make an effective connection from the ground grid through the SVC building to all equipment, control panels, each instrument rack, several points on cable tray support steel, and each conduit that shall be used to pull conductors into the building. The Contractor shall be responsible for a complete and effective ground system.

All work shall be well braced, closely fitted, thoroughly connected, accurately set, and rigidly secured in place. The structure shall be constructed in conformance with the best workmanship practices and building codes, making it square, straight, level, and properly installed on the foundation.

Sealants shall be installed at all joints as required to achieve a wind and water tight condition. All sealant work shall be done in a neat manner. Excess sealant shall be removed from exposed surfaces.

3.6.2 Doors and Hardware

All doorways and openings shall be sized for convenient passage of personnel, equipment and materials. Transom panels are not acceptable. Exterior doors shall be 18 gauge steel, swinging out, flush design filled with mineral fiber insulation. Where required, doors shall be fire rated. Hinges shall be bronze butt. Hinge pins shall be unremoveable type by means of a set screw in barrel nonremoveable when door is closed.

Overhead or roll-up equipment doors shall be insulated, and shall be provided with an adequate bottom weather strip. Tracks for overhead doors shall be galvanized.

All hardware of each kind shall be a product of one manufacturer (i.e. all locks shall be product of one manufacturer, closers shall be product of on manufacturer, etc.) and shall be of a standard commercial quality suitable for its intended use. All locks shall be keyed alike and shall match the locks at the Kandahar East Substation.

3.6.3 Painting and Finishes

All surfaces of the SVC building shall be painted except surfaces having a factory-applied coating or surfaces not designed to be painted. The Contractor shall submit a color scheme and list of materials for approval by the Employer. Protect nameplates, cover plates and other surfaces from paint and damage. Furnish drop cloths, shields, or protective equipment to prevent spraying or droppings from fouling surfaces not being painted.

Materials furnished for each coating system must be products from a single manufacturer and compatible with the substrate. When shop-painted surfaces are to be coated, determine whether finish material will be compatible with the shop coating.

Preparation of surfaces to be painted shall be in accordance with the manufacturer's instructions. If solvents are used, the surfaces shall be cleaned of all defective or damaged areas of existing paint and of all loose rust, mill scale, excess mortar, loose particles, and other foreign substances. Surfaces with gloss or semi-gloss paints shall be lightly sanded. Wood surfaces shall be sanded prior to painting. Nail holes, cracks and similar imperfections shall be filled.

3.6.4 Lighting and Fire Protection

3.6.4.1 Lighting and Electrical Systems

The Contractor shall design, furnish and install all material and equipment and perform all work necessary to complete, test, and make ready for operation the lighting and electrical systems for the SVC building. The design of the building lighting and electrical systems shall be in accordance with proven design methods, local codes and accepted industry standards.

The Contractor shall furnish and install all luminaries complete with all lamps, ballasts, luminaire fuses, luminaire wire and cord, mounting hardware and accessories necessary to complete the installation of the luminaries.

Minimum lighting levels for the control room shall be 970lux. Minimum lighting levels for unfinished and equipment areas shall be 540lux.

Emergency lighting units shall be self-contained units that operate automatically upon loss of station service power. Emergency lighting shall be installed at critical locations as required for safety of personnel and where required for restoration of the station lighting system.

3.6.4.2 Fire Protection and Alarm

The Contractor shall design and install a fire protection system that conforms to national and local codes. The fire protection system design and associated alarms shall take into account that the SVC will be unattended at most times. Selection and location of automatic detectors shall suit the application, and shall consider conditions such as high voltage fields, air velocity and environment to minimize nuisance alarms.

The system shall be electrically supervised against failure of the detection and alarm circuits. In case of failure of a detector or alarm circuit, a visual and audible alarm different from a fire detection alarm shall be initiated on the station fire alarm control panel. Detectors shall be capable of being tested, having maintenance performed on them or being replaced without impairing the operation of the SVC, except for detectors located in areas where personnel access is not allowed during SVC operation.

Operation of any manual alarm or automatic detector shall cause the initiation of the visual and audible alarm on the station fire alarm control panel, indicating the area of the location of the originating alarm. Alarms shall initiate automatic shutdown of the air-conditioning, ventilation and exhaust systems in the area of the fire. A manual override of this function shall be provided for exhaust systems that could be used for smoke removal. All alarms shall initiate audible signals and visible flashing indicators that shall continue until the system is reset. Operation of detectors in the valve hall shall trip the SVC.

The fire alarm control panel shall be located in the control room and shall include all devices necessary to permit the operation of the fire alarm system. All fire alarms shall be identifiable as to location. Standby power from an uninterruptible source shall be provided. The uninterruptible source shall be sufficient to provide electrical supervision and support of the normal system for a minimum of 24 hours.

The Contractor shall provide portable fire extinguishers in the control and equipment areas.

3.6.5 Heating, Ventilating and Air Conditioning

Air conditioning, heating, ventilation, and/or environmental controls systems shall be provided to ensure satisfactory operation of the station under the range of climatic conditions to which the station may be subject.

The HVAC systems shall include energy conservation design features that can minimize station service energy, be economically justified, and suitable for the area served. In areas where environmental control is essential to ensure proper operation, back-up systems shall be installed. Heating and air conditioning temperatures shall be thermostatically controlled.

The design of the HVAC system shall be primarily based on the operation requirements of the SVC equipment installed. It shall be the sole responsibility of the Contractor to provide reliable systems that satisfy these requirements. Regardless of equipment requirements, supplemental heat will be required when the SVC is off line, workers are present, and outside temperatures are low. Control room HVAC systems shall be designed for the comfort of personnel.

Air intakes shall incorporate snow and rain exclusion devices and filters for removal of airborne plant material, insects, and birds. If necessary, devices for controlling ambient noise shall be included.

3.7 Testing Requirements

The Contractor shall be responsible for compliance with all standard test procedures that shall progressively check the quality and performance of the SVC equipment.

The Contractor shall perform those design, production and commissioning tests specified below and in other sections of this specification. The Bidder shall propose additional tests that will be conducted. The completeness of the proposed tests will be a factor in the bid evaluation. Where appropriate, tests shall conform to those contained in IEC standards and guides. Where standards are not suitable or applicable, other common industry procedures and mutually acceptable methods shall be used.

If certain design, production or commissioning tests are performed by manufacturers other than the Contractor, the Contractor has the responsibility to furnish the test reports and certify that the necessary testing has been performed.

If the SVC manufacturer will not be present for the field tests, the communications link between the SVC control and the manufacturer's facilities shall be completely tested and operational prior to the start of any field operating tests.

3.7.1 Factory Testing

The Contractor shall develop and submit a factory test plan. As a minimum, sufficient tests shall be conducted to demonstrate that all controls, protective functions and instrumentation perform as designed and is in compliance with this specification. Successful tests performed on scale models or digital simulators will be deemed to meet the intent of this paragraph.

All equipment to be supplied by the Contractor shall be subjected to routine and design tests in the factory as required under the specifications for each piece of equipment. Equipment with complex interfaces with other equipment, such as the SVC controls, shall be connected and tested as a system in the factory. The tests shall demonstrate full implementation and compatibility with the Employer’s communication system and protocol.

The Contractor shall indicate in his proposal all the factory design and production tests which will be performed on all major components and parts. Standard tests previously performed on certain equipment may be acceptable. For standard items such as capacitors, and high power semiconductor devices, such reports on previously performed tests will generally be acceptable. However, for the major items such as the transformers, breakers, control system and cooling systems applicable specific performance tests will be required.

The test data shall be complete including drawings and shall clearly station the performance of the equipment subjected to the test. If the test data is for standard tests performed on equipment other than that being provided under this contract, the Contractor shall include a statement that equipment being furnished is identical in all respects to the equipment on which the particular test was performed.

3.7.2 Pre-Commissioning Field Tests

The Contractor shall perform pre-commissioning field tests on the fully assembled SVC facility with the SVC disconnected from the 220kV source. The tests shall be performed on all equipment to ensure that no damage occurred in transit, that all equipment has been properly installed, is correctly set, and is functioning correctly.

Pre-commissioning tests shall include, but not be limited to, the following:

- Dielectric and insulation resistance tests on all equipment connected to the 220kV system, consisting of power factor tests and hi-pot tests.
- Ratio and polarity tests on transformers and instrument transformers
- Insulating oil tests on transformers and other oil-insulated equipment
- Functional tests on auxiliaries
- Functional tests on control, protection and alarm circuits, including relay and control settings
- Functional tests of all interlock systems
- Wiring continuity and insulation resistance tests
- Diagnostic software functional demonstration
- Alignment and adjustment of all disconnect switches

- Verification and adjustment of cooling system
- Calibration and adjustment of all gauges, meters and instruments
- Measure grounding system resistance
- Capacitance test of capacitor cans

In addition to the above tests, the Contractor shall energize or start up all independent subsystems. These tests shall demonstrate the electrical and mechanical integrity of these subsystems. During these tests, the Contractor shall make the initial adjustments to the equipment required for satisfactory operation.

Following the successful completion of the above tests, the Contractor shall perform system tests as required to demonstrate the proper functioning of the associated controls and protection. Such tests may include trial operation during which the Contractor shall make final adjustments to the equipment for satisfactory and proper operation.

3.7.3 Acceptance and Performance Tests

After successful completion of the pre-commissioning tests, the Contractor shall perform acceptance and performance tests to demonstrate that the SVC performs as specified. All modes of operation as described in these specifications shall be tested. Prior to proceeding with acceptance and performance tests, the Contractor shall determine that the SVC is fully operational and suitable for acceptance testing. Tests shall include verification of all sensors, meters, alarms, control functions, including automatic, local and remote control, and performance criteria.

The Contractor shall coordinate with the Employer for all tests where the SVC is to be connected to the Employer's power system. No such tests shall be performed unless permission by the Employer has been granted. The tests must be performed in a fashion to minimize unanticipated disturbances on the power system. These tests may have to be performed during the night or low load periods for certain types of tests.

The Contractor shall document all acceptance and performance tests performed. The Contractor shall submit documentation, analyses, and a summary in a test report for the Employer's records.

3.7.3.1 Function Tests

After the SVC has been installed, the Contractor will perform comprehensive testing on the entire system to verify compliance with all requirements of this specification. Testing shall include, at a minimum, the following tests.

- Verify change of reference point and slope both locally and remotely
- Verify the automatic start-up and shutdown sequences, including restart following undervoltage trip. This includes both those that are initiated automatically by the SVC controller, and manually by a system operator from both local and remote locations.
- Verify the automatic sequences of blocking and unblocking the valves.
- Demonstrate the repeatability of control system functions such as voltage set-point changes.
- Operation of all control, protective relaying, and instrumentation circuits shall be demonstrated by direct test if feasible or by simulating operating states for all parameters

that cannot be directly tested. Automatic, local, and remote operation will be demonstrated.

3.7.3.2 Performance Tests

The SVC performance verification shall include tests as determined by the Contractor to verify that the performance criteria specified in these specifications can be met or exceeded. Accordingly, the Contractor shall provide a total system performance verification plan to ensure correct SVC response to system disturbances and operating scenarios described in this specification. The total system performance verification plan shall be submitted to the Employer for review and approval 60 days prior to SVC performance tests.

At a minimum, the following performance tests shall be performed.

- Measurements of harmonic content at full and partial output levels.
- Measurement of losses
- Interference measurements
- Tapchanger control (if provided)
- Operating mode transfers
- Performance under system disturbances and faults
- AC and DC auxiliary supply changeover or failure
- Demonstrate and measure the SVC system operation and performance under prevailing system condition for a continuous 48 hour period.

The Employer will not accept the SVC until all acceptance tests have been successfully completed.

3.7.3.3 Actual Operating Experience:

It may not be possible due to system constraints to test all facets of the SVC function as part of the performance verification tests specified above. The actual operating experience of the SVC system through the warranty period shall be deemed an extension of the performance verification tests.

Actual operating experience will be documented through Contractor furnished sequence of event recorders, digital fault recorders and other system monitoring equipment capable of identifying system disturbances and associated SVC performance.

Documented failure or malfunctions of any SVC component during the warranty period shall be deemed as a failure of the system commissioning test. The Contractor shall, at no cost to the Employer, make the necessary repairs, replacements, modification or adjustment to prevent the same failure or malfunction from occurring again. The replacement of certain SVC components in response to a system failure, may necessitate, at the discretion of the Employer, the duplication of certain performance verification tests which shall be performed at the Contractor's expense.

3.8 Training

The Contractor shall provide training for the SVC facilities as specified below. The Contractor shall determine the content and duration for each training session. The Contractor shall provide all material and equipment, as well as qualified fluent Dari speaking instructors, to conduct the training program. It is preferred that as much of the training as practical be held at the SVC site.Classroom sessions may be held in a convenient location close to the site with site visits to supplement the training. Preliminary information on the content of each training session shall be submitted with the proposal.

Training manuals shall be provided to each trainee attending each course. At the completion of each course, the training manuals and any other training aids shall become the property of the Employer.

The suggested class durations in this specification are meant to illustrate the level of training expected. In preparation of the course material, the Contractor shall consider that the Employer’s personnel are familiar with substation equipment, including control, protection and communications. The Employer’s personnel are not familiar with power electronics and associated systems.

Training shall be conducted in Dari in Afghanistan.

Training shall be videotaped and provided to Employer for reference in the future.

3.8.1 Orientation Training

The Contractor shall provide one Orientation training session. It is anticipated that the Orientation training will be held over a two-day period with one 4-hour session per day. These sessions shall be suitable for managers, supervisors, professional and technical personnel. Each session will be limited to a maximum of 12 people.

The orientation training session shall be scheduled before commencing SVC performance verification tests. An outline for this orientation training shall be submitted to the Employer 90 days ahead of the actual date of training. Approval of this outline shall be obtained from the Employer. The Employer will provide comments and/or approval 30 days before the scheduled training date.

3.8.2 Operator Training

The Contractor shall provide the necessary training in proper operation of the SVC and related equipment. This training shall be conducted after completion of the SVC performance verification testing, but before system commissioning. The training shall thoroughly familiarize the operating personnel with the various aspects of the SVC including operation from a SCADA system so that at the completion of the training they will be able to completely and properly operate the SVC equipment without Contractor assistance. Emphasis shall be placed on hands-on operating experience interspersed with the critical background as necessary, including switching procedures and emergency response training.

The Contractor shall provide two Operator training sessions to accommodate a rotating shift schedule. It is anticipated that this session will last 1-2 days. Each session will be limited to a maximum of 12 people.

3.8.3 Emergency Procedures Training

The Contractor shall provide the necessary training in emergency procedures to allow the Employer’s personnel to respond to emergencies at the SVC. Such training shall include emergency shutdown procedures, switching to isolate the SVC, fire procedures, and any other procedures the Employers maintenance personnel may be required to respond to.

The Contractor shall provide one Emergency Procedures training session. It is anticipated that emergency procedures training will last 1 day. Each session will be limited to a maximum of 12 people.

3.8.4 Maintenance Training

The Contractor shall provide necessary training in maintenance of the SVC and related equipment. The maintenance training shall be scheduled after successful commissioning of the SVC. The training shall thoroughly familiarize the maintenance personnel with the various aspects of the SVC. Maintenance training shall include preventative maintenance as well as troubleshooting. Maintenance of digital controls and microprocessor control systems used in the SVC shall be emphasized. At the completion of training, the maintenance personnel should be able to completely and properly maintain the SVC facility without Contractor assistance. The maintenance training shall include, but not be limited to:

- Normal maintenance methods
- Repairs and replacement
- Diagnostic procedures
- Equipment calibration
- Re-energization
- Special tests
- Special tools
- Safety and grounding procedures

The Contractor shall provide two Maintenance training sessions. It is anticipated that maintenance training will last 1-2 days. Each session will be limited to a maximum of 6 people. The Maintenance Training shall be recorded by the Contractor and provided to the Employer on DVD for use in training new personnel and as a refresher course.

3.9 Maintenance and Spare Parts

The SVC shall be designed so that regular maintenance may be carried out by either the Contractor (under a separate contract) or by the Employer.

3.9.1 Maintenance by Contractor

The Employer may desire to have maintenance of SVC major systems performed by the Contractor under a separate contract. Under this contract, the Contractor would supply all labor, equipment and materials needed to maintain system performance and safe operation. The Contractor shall delineate the services it would perform under this option along with the price for the Employer to exercise this option.

In the interest of reducing maintenance costs under this option, the Contractor may propose that certain non-specialized maintenance activities be performed by Employer personnel. These activities may be excluded from the Contractor's maintenance contract, but must be fully described, including estimated manhours and frequencies. Such activities shall not include activities, the proper or timely performance of which are required for maintaining adherence to the Contractor’s warranty terms and conditions.

The Contractor shall submit with the proposal a complete maintenance contract, including proposed terms and conditions for the Employer’s review.

3.9.2 Maintenance by Employer

The Employer may elect to operate and maintain all equipment for the SVC with its own personnel. To support this, the Contractor shall design and supply equipment with commercially available, "off the shelf" parts to the extent possible.

The Contractor with the assistance of its major equipment suppliers shall conduct training classes for Employer maintenance personnel at the site.

The Contractor shall remain available by telephone, e-mail or fax and provide consultation and required repairs for the Employer if the system malfunctions during the warranty period.

In its proposal, the Contractor shall supply a description of all major maintenance activities, including estimated man hours and frequencies of occurrence for each activity.

3.9.3 Spare Parts

The Contractor shall evaluate its design with regard to failure rates, effects and SVC reliability and availability. The Contractor shall provide a recommended spare parts list, including prices and availability, as part of his proposal. Spare parts that are readily available from stock and available within sufficient time to meet the required availability shall be considered off-the-shelf items and not required as spare parts in stock at the site. These parts shall be listed and so noted on the spare parts list. The Employer will determine the need for and purchase separately all spare parts.

All spare parts for equipment covered by this specification shall be interchangeable with the original equipment and shall comply in all aspects with the requirements of this specification. This includes documentation identical in kind and format to that required for the original equipment or material.

3.9.4 Tools and Equipment

The Contractor shall provide all “special tools and equipment” for maintenance and operation which are not normally or readily available. The Contractor shall submit, with the proposal a complete list of tools and equipment needed for erection/installation and maintenance and a list of special tools and equipment that will be provided, including prices. Special tools and equipment shall become the property of the Employer at the completion of the SVC installation. The Employer reserves the right to purchase additional quantities of tools if desired. Specifically include capacitor test set, electronic card extenders and any special cable assemblies and configured PC with operating system with a license prepaid for ten years.

The Employer will supply common tools and maintenance equipment. Common tools and maintenance equipment in this context shall mean tools and maintenance equipment available commercially from two or more independent suppliers. The Contractor will supply all common tools and maintenance equipment throughout the maintenance contract should the Employer exercise this option.

3.10 Documentation

3.10.1 Document Submittal Quantity and Procedures

The Contractor shall furnish complete documentation that will be used for determination of contract compliance, as well as, operation and maintenance of the SVC. The documentation shall be in accordance with the documentation section of these specifications.

At a minimum, Contractor's documentation shall consist of the following:

- Construction and Installation Drawings
- Construction Materials Submittal
- Equipment Drawings and Specifications
- Operation and Maintenance Manual
- Maintenance Schedule
- Master Test Plan and Procedures
- Quality Assurance Manual
- Software Documentation
- Study Reports
- Test Reports
- Training Manuals

3.10.2 Maintenance Schedule

The Contractor shall prepare a comprehensive maintenance schedule listing required maintenance for all equipment based on specific maintenance triggers. This schedule will cover the equipment design life and make direct reference to maintenance requirements listed in the Operation and Maintenance Manuals. The maintenance schedule shall include an estimate of the man-hours and equipment required to complete each task.

3.10.3 Master Test Plan and Procedures

The Contractor shall submit a Master Test Plan and Procedures indicating the order in which the tests will be conducted and the test method being used along with required instrumentation. The test plan shall include all types of tests required by these specifications and shall demonstrate that a complete testing plan is being proposed.

3.10.4 Study Reports

The Contractor shall submit all design study, simulation and field test reports to the Employer in a timely manner in accordance with the documentation requirements. These reports shall contain assumptions, study methods, results, significant findings and conclusions. The Contractor shall submit reports for all studies required by these specifications.

3.10.5 Test Reports

The Contractor shall prepare test reports. Formal test reports are required for all tests listed in the Master Test Plan and Procedures. The test reports will include the subject test plan, required data, test results and discrepancy reports or failure reports resulting from performance of the tests.

3.10.6 Training Manuals

45 days prior to the start of training, the Contractor shall provide draft training manuals and course outlines for review. The training manuals will include relevant portions of the Operation and Maintenance Manuals and Software Documentation and will be retained by the Employer. The Employer shall have the right to reproduce any training manuals for their own use.

3.10.7 Operation and Maintenance Manuals

The Contractor shall furnish operation and maintenance manuals for all the equipment as applicable. Clarity and readability shall be of the highest commercial standards. The books shall be oriented toward operation and maintenance of the equipment without the services of a manufacturer’s representative. The portions devoted to descriptive matter and theory shall be limited to those that are essential to a proper understanding of the equipment for satisfactory operation and maintenance. The Employer shall have the right to reproduce any Operation and Maintenance manuals for their own use.

3.10.7.1 Information

The operation and maintenance manuals shall include, but are not limited to, the information specified below.

- Manufacturer’s Definitions: All terminology peculiar to the Contractor’s equipment shall be clearly explained by the Contractor in a supplementary section bearing the heading "Definitions."

- Factory Specification of the Equipment

- Shipping Instruction, Warehouse Storage, and Handling Instruction: List major components for warehouse inspection, and site receiving and storage instructions.

- Parts and Factory Service Instruction: Factory repair policy shall be provided. Describe in detail the procedure to obtain spare parts or factory service: (1) under normal conditions, (2) under emergency conditions. Specify the mailing address and telephone number(s) of the service department.

- Installation Instructions: Installation instructions and information to supplement the installation drawings shall be furnished. This information shall include power requirements, assembly procedures, safety precautions, grounding instructions, alignment instructions, installation test requirements, and details associated with equipment testing to verify proper performance.

- Preventive Maintenance Instructions: Preventive maintenance instructions shall be furnished for all subsystems indicating manufacturers’ recommended maintenance intervals based on specific maintenance triggers. These instructions shall include required test procedures, alignment instructions, cleaning requirements and instruction for visual examinations.

- Maintenance Schedule: The maintenance schedule shall include maintenance trigger points for each type of equipment. Such trigger points shall identify monitored parameters that can be used to perform preventative maintenance when needed based on operating conditions rather than time based maintenance. The preventive maintenance instructions shall include a table indicating the average man-hours required to complete a maintenance action, outage time if required and on-line/off-line requirement for the maintenance action.

- Troubleshooting Instructions: Troubleshooting instructions shall be to the spare parts level with adequate details for quick and efficient location of cause for equipment malfunction. Include adjustment limits, timing diagrams, troubleshooting and recommended corrective action steps, and resetting requirements before return to service. For mechanical items, information on tolerances, clearances, wear limits, and maximum bolt-down torques shall be supplied.

- Parts information: This section shall contain a complete parts list and subsections which include a breakdown to the smallest assembly considered a replacement part, showing name and description, catalog number, quantity used, and reference by item number on the applicable drawing. The description shall include electrical and mechanical ratings, settings, nameplate drawings, additional instructions or instruction books, testing requirements, wire list, curves, drawings, and inspection and installation instructions.

- Spare Parts: A list of spare parts as recommended by the manufacturer, including the descriptive information listed in the preceding paragraph.

- Tools Information: A list of all tools needed to install or maintain the equipment shall be provided in this section. Tools shall be identified by either the Contractor’s part number or manufacturer’s part number and cross-referenced where applicable. All special tools supplied with the equipment shall be identified as such on the tool list.

- Theory of Operation: Include a system overview and detailed information pertaining to the individual systems and subsystems that make up the SVC, as shown on a Contractor supplied outline, logic, schematic, and one-line diagrams. The SVC control and protective functions shall be numbered and cross-referenced to insure easy identification on the above diagrams. Specifically the Contractor is required to provide narrative describing the control and protective logic of each function such that the operating principles can be readily understood. Portions devoted to describing fundamental theory shall be limited to those that are essential to a proper understanding of the equipment operation.

- Controller User Interface: The instructions shall describe the Controller User Interface in detail and specifically include instructions and examples for calculating and setting all user controlled parameters. The description shall identify in detail exceptional system conditions (if any) where the conventional settings may have to be altered.

- Installation Procedure: This section shall include a detailed step-by-step instruction of the SVC test procedure and calibration. Additional information shall include power requirements, assembly procedures, safety precautions, grounding instructions, and installation test requirements.

3.10.8 Digital Controller Software Documentation

All controller software and any subsequent fixes, patches, or upgrades shall be fully documented. The Software Design Document shall detail the design of the controller software. This document will include the following types of information.

3.10.8.1 Software Overview

The Software Design Document shall provide an overview of the controller software. This overview shall include a list of controller algorithms and a description of how each of these algorithms interrelates with the others. This description shall either be provided as a narrative or as software control flow diagrams.

3.10.8.2 Documentation of Individual Modules

The Software Design Document shall include separate documentation for each controller module or algorithm. Information specific to individual modules or algorithms shall include:

- A functional description of the module.
- A Data Flow Diagram that depicts the interfaces between the module and other controller software routines.
- A Module Interaction Summary that narrates the information presented in the Data Flow Diagrams.
- A list of GLOBAL data elements used within the module, including a full description of each data element, its type, how it is used, and its range of values.
- A list of LOCAL data elements used within the module, including a full description of each data element, its type, how it is used, and its range of values.
- A list of control inputs required by the module.
- A list of outputs directly affected by the module.
- A Pseudocode (structured English) description of the algorithm’s high level design.
- Other information required for an understanding of the function of the algorithm.
- PLC code, logic diagrams and/or ladder logic diagrams.

3.10.8.3 Data Dictionary

The Data Dictionary shall be an alphabetically arranged source of information on each data element used in the controller software system. The Data Dictionary shall provide a description of each data element used in the controller software, including descriptions of:

- Data element type.
- Data element use by the Applications Software.
- The acceptable range of values for the data element.
- The program modules in which the data element is used.

3.10.8.4 Error Messages List

The Error Messages List shall be a source of information on error messages issued by the controller. This information shall include a description of the type and meaning of each error message, how it is used, and what corrective action is required to solve the problem. The Error Message List shall include information on:

- Error messages generated by the Operating System
- Error messages generated by the Hardware Diagnostics
- Error messages generated by the Applications Program

3.10.9 Digital Controller Hardware Documentation

The contractor shall provide manufacturer standard specifications and model numbers of all controller hardware.

3.10.10 Relay and Control Settings

The contractor shall provide complete documentation of all protective relay and SVC control settings. Such documentation shall include all calculations and coordination curves used in the development of the settings.

3.11 Warranty

3.11.1 Twelve Month Construction Warranty

Contractor warrants that all Work performed under this Contract shall be in accordance with the Contract documents and specification and all applicable national and local laws and regulations in existence at the time of execution of the Contract. Contractor makes all such warranties for a period of twelve (12) months after the date of final acceptance of the project by the Employer.

If it is demonstrated within the warranty period the Work fails to meet the provisions of this warranty, Contractor shall promptly correct any defects, including, nonconformance with the specification, either, at its option, by adjustment, modification, repair, or replacement of all defective parts or materials (Correction Measure), including adjustment, repair or replacement of any portion, component, part and/or assembly.

Contractor shall be required, at its expense, to take any or all of the Corrective Measures to correct any defects and deficiencies in the Work before and during the warranty period, including without limitation, transportation expenses of equipment and personnel to and from the job site, and in and out expenses.

All Corrective Measures taken by the Contractor shall be subject to Warranty for twelve (12) months from the date of the Corrective Measure for the corrected portions. If Contractor, after written notice from Employer, fails to proceed to correct defective Work or otherwise to comply with the terms of Contractor’s Warranties, Employer may have the Work corrected as it deems appropriate and Contractor shall be liable for all expenses incurred to correct the defective Work by Employer to include without limitation Employer’s overhead costs.

Contractor does not warrant the Work or any required repairs or replacement under this provision against normal wear and tear including those due to operation or environment. The Work must be operated and maintained in accordance with Contractor’s instructions and prudent utility practices.

The liability of Contractor under this warranty (except as to title) shall constitute the exclusive remedy for all equipment damage claims based on failure of, or defect in, goods or services sold hereunder, whether the failure or defect arises before or during the warranty period, and whether such claim, however instituted, is based on Contract, indemnity, guarantee, tort, (including negligence), strict liability or otherwise. The foregoing warranty is exclusive and is in lieu of all other warranties whether written, oral, implied, or statutory. As to all goods sold, no implied statutory warranty of merchantability or of fitness for particular purpose shall apply.

4.0 Mechanically Switched Shunt Reactor

4.1 Reference Standards

All shunt reactors shall be designed and manufactured in accordance with the latest edition of IEC standards. This includes the following main applicable standards:

- IEC 60076 Power Transformers
- IEC 60137 Insulating bushings for alternating voltages above 1000V
- IEC 60296 Fluids for electrotechnical applications - Unused mineral insulating oils for transformers and switchgear
- IEC 60529 Degrees of protection provided by enclosures

4.2 General Design

Shunt reactors shall be 3 phase, oil immersed consisting of a complete independent unit with outdoor bushings, surge arrestors, cooling equipment, auxiliaries and accessories. All shunt reactors supplied shall be installed outdoors and shall be required to operate under the system characteristics and climatic conditions specified in Section 3.1.5 and 3.2.1. Each shunt reactor shall produce its full rated reactive power at its designated substation after applying any derating factors due to climate and altitude. The shunt reactors shall comply with IEC 60076.

The shunt reactors shall be located and rated in accordance with table 2.2 of the specification.

The shunt reactors shall be capable of operating continuously at the specified output and at voltages at 10% higher than the rated voltages without undue heating, vibration, noise and other operating difficulties.

The electrical supply will be 400/230VAC available for operation of electric motors required for the proper operation of the shunt reactor.

4.3 Design Parameters

Mechanically Switched Reactors (MSRs) shall be chosen to meet these requirements.

A. Line Energization

1. Sequential energization of the individual line segments between substations, beginning at Arghandi, shall be possible under these conditions and without exceeding these parameters:

    a. Heavy loading, strong source, Uzbekistan source power flow case provided by Employer. No load served by the Arghandi SS to Kandahar East SS transmission line system.

    b. Chimtala 220kV bus voltage of 1.00 per unit (pu) prior to switching each line segment.

    c. Reactive power flow between the Arghandi SS to Kandahar East SS transmission line system and the Chimtala bus between –15MVAr (reactive power entering Chimtala bus) and +15MVAr (reactive power leaving Chimtala bus). Reactive power flow at Chimtala shall remain between these limits throughout the switching sequence.

d. After switching in the line segment the Chimtala 220kV bus voltage must be between 1.05pu and 0.95pu and the change in reactive power flow at the Chimtala bus less than 15MVAr from the initial state, WITHOUT changes in RPC except for MSRs associated with the line segment being energized.

e. Maintain voltages at substations along the Arghandi SS to Kandahar East SS transmission line system between 1.05pu and 0.95pu throughout the entire switching sequence.

f. SVC at Kandahar East SS to remain off during this test.

B. Line De-energization – No Load

1. De-energization of line segments by opening circuit breakers beginning at Arghandi SS and at each substation proceeding down the line toward Kandahar East SS shall be possible under these conditions and without exceeding these parameters:

a. Heavy loading, strong source, Uzbekistan source power flow case provided by Employer. No load served by the Arghandi SS to Kandahar East SS transmission line system. Transformers de-energized.

b. Chimtala 220kV bus voltage of 1.00 per unit (pu) prior to every switching operation.

c. Testing shall include opening one circuit of the double circuit line between each substation and opening both circuits of the line (as would occur for a tower failure affecting both circuits).

d. It shall be permissible to de-energize one or more MSRs simultaneously with opening of line circuit breakers so long as 1) the MSRs are located in the same substation with the circuit breaker which is operating and 2) simultaneous tripping of the line and reactor(s) is included in the protection and control functionality.

e. Reactive power flow between the Arghandi SS to Kandahar East SS transmission line system and the Chimtala bus between –15MVAr (reactive power entering Chimtala bus) and +15MVAr (reactive power leaving Chimtala bus).

f. Chimtala 220kV bus voltage between 1.05pu and 0.95pu and the change in reactive power flow at the Chimtala bus less than 15MVAr from the initial state, WITHOUT changes in RPC except for MSRs associated with the line segment being de-energized.

g. Maintain voltages at substations along the Arghandi SS to Kandahar East SS transmission line system between 1.05pu and 0.95pu throughout the entire switching sequence.

h. SVC at Kandahar East SS to remain off during this test.

4.4 Losses

The losses shall be stated and guaranteed in the Bid schedules. The capitalized value of the guaranteed losses will be taken into account when comparing Bids and will be added to the Bid price. The losses will be capitalized at the rates and using the methods described in WO-LT-0048 2.4.2.3.

The guaranteed losses are to be maximum values and shall not be exceeded. If the tested losses exceed the guaranteed losses but are within the tolerances allowed in IEC 60076 then losses in excess of the guarantees shall be capitalized at the evaluation rate and the amount deducted from the contract price. There will be no credit for losses under guarantee.

The values for losses stated by the Contractor in the Bid Documents shall be verified during the factory tests.

The Employer has the right to reject shunt reactors that exceed the tolerances allowed by IEC 60076.

4.5 Cooling System

Shunt reactors shall be capable of operating continuously at full load utilizing ONAN type cooling. The coolers shall be of the fin type, fully hot-dip galvanized, detachable and equipped with lifting eyes, vent holes with plugs, plugs for filling and draining and with shutoff valves to permit the removal of any cooler without draining the oil from the shunt reactor tank. The coolers shall be removable during operation of the shunt reactor. All radiator isolating valves shall be fully oil tight and vacuum capable and shall be mounted to the shunt reactor and radiator by bolted flanges.

Only shunt reactors less than 10MVA shall have radiators mounted directly to the tank, all other shunt reactors shall be mounted via a manifold.

4.6 Temperature Rise

In continuous service, at the specified ratings, the rise in temperature above the ambient air shall not exceed 60°C for the windings and 55°C for the top oil.

For cores and other parts the rise in temperature shall, in no case, reach a value that will damage the core itself, metallic parts or adjacent materials.

4.7 Short-Circuit Withstanding Capability

The shunt reactor shall be designed and constructed to withstand without damage:

- Thermal and mechanical effects of any short-circuit (three-phase short-circuits and solid line-to-ground short circuits, etc.) that can appear at the terminal of any winding.

- Transportation or impact forces of 3g or greater.

4.8 Vibration and Noise Levels

Special attention shall be given in order to avoid undue vibrations and noise in the shunt reactor.

4.9 Core

The flux density in the core shall not exceed 1.70 Tesla during normal operation at rated primary voltage on nominal tap and at rated frequency with no over-fluxing occurring.

The core shall be made of high grade, unaging, cold rolled grain oriented steel. Laminations shall have low losses and high permeability. Insulated packets of the core are to be connected so that no potential differences will exist between them. Flux distortion shall be minimized to reduce noise level.

The cores, framework, clamping arrangements, shall be capable of withstanding any shocks to which the equipment may be subjected during transport and operation.

Both the core and frames shall be earthed via a single point earthing design where each connection to either the frame or core is brought out through separate 2kV bushings complete with removable bolted shorting links that connect them to an earth stud on the tank lid. All components shall be rated for the maximum possible circulating current should the core or frame become inadvertently earthed. The bushings located on the lid shall be protected from inadvertent physical damage by a removable cover or similar.

4.10 Windings

The turns in coils shall be thoroughly treated in such a way as to develop the full mechanical and electrical strength of the shunt reactor. Oil from radiators shall be directed into the bottom of each winding.

All windings 220kV and above shall have graded insulation; and all windings rated less than 220kV shall be fully insulated.

All winding conductors and connections shall be manufactured from burr free profiled high conductivity copper or aluminum. All electrical connections within the windings shall be fully brazed or welded and capable of withstanding all shocks encountered in service, transport, earthquakes etc. All connections from windings shall be mechanically sound and fully supported.

All cylinders and wraps shall be made from pre-compressed transformer board. All cylinder joints shall be fully scarffed with overlaps being made only on duct strips. Only fully molded caps and collars are acceptable; designs utilizing “Petal” collars or caps are not acceptable.

When used, enamel covered wires shall have a minimum radial thickness of 0.05mm and where cross-overs or transpositions occur they shall be mechanically and electrically protected.

No electrical out-of-balance turns will be acceptable between phase windings. All duct strips and spacers shall be full contoured and shall be of a solid construction, strips and spacers stacked together are not acceptable. All paper-covered conductors shall use thermally upgraded paper. All continuously transposed conductors shall be fully epoxy bonded to withstand all free buckling and short circuit forces.

4.11 Tank

The tank shall be constructed of high-grade steel plate, suitable reinforced to withstand handling and pressure during fault condition without any destruction. The tank shall be provided with manholes, valves and de-aerating cocks as may be required for the prescribed maintenance of the shunt reactor. The tank shall be provided with earthing terminals for a wire of $95mm^2$ at two opposite sides of the tank.

4.12 Corrosion Protection

The corrosion protection shall be carried out as specified in WO-LT-0048.

4.13 Oil

All oil used during the manufacture of the shunt reactor shall be free of all additives. Oil supplied for the filling of the shunt reactor shall be new and shall contain at least 0.3% by weight oxidation inhibitor of type di-tert-butyl-para cresol (DBPC) according to IEC 60296.

The oil shall not contain PCB. If oil samples taken from the shunt reactor on delivery contain 2ppm or more PCB, the Employer shall have the right to refuse the delivery of the shunt reactor.

4.14 Bushings

Bushings shall be of type stated in IEC 60137.

Connections from the windings to the bushings shall have the necessary flexibility. The bushings shall be installed so that they are easy to check and place, without removing the tank cover pipe work.

The star point of the winding shall be separately bought out through the tank lid by means of an outdoor bushing, located so that it cannot be associated with the main phase bushings. All bushings shall have permanent phase markings adjacent to the bushing flange.

4.15 Accessories

The following accessories shall be provided for the shunt reactor:

- Oil temperature indicator for the top oil equipped with a maximum reading device individually insulated and a minimum of two separately adjustable contacts for alarm and tripping, with all immersed parts able to be removed without the need to interfere with the tank

- Winding temperature indicator shall be equipped with a maximum reading device individually insulated and a minimum of two separately adjustable contacts for alarm and tripping, with all immersed parts able to be removed without the need to interfere with the tank

- An aseismic Buchholtz relay for gas protection with a minimum of two non-mercury separate contacts for signal and tripping. A gas capture and test device shall be connected to the Buchholtz and located adjacent to the control cubicle

- Oil level indicator equipped with a minimum of two separately adjustable contacts for alarm and tripping

- Oil drying device, type Silica Gel breather

- Terminal box equipped with disconnect able terminals for signal cables to the auxiliary cubicle

4.16 Routine and Type Tests

4.16.1 General

Full and complete testing of the shunt reactor with accessories shall be carried out according to the relevant IEC Standards. The more important tests are listed below.

The Contractor shall give a complete description of the proposed test methods. The test methods and the performance of the test shall be subject to the approval of the Project Manager. All instruments and equipment necessary for the testing shall be provided by the Contractor.

4.16.2 Test Particulars

Testing shall include but not be limited to the following:

- When a shunt reactor is to be subject to a temperature rise test, dielectric test including an impulse test shall be carried out as soon as practicable after this test, that is whilst the shunt reactor is still hot

- The no-load losses and the current of the shunt reactor shall be measured at 90%, 100% and 110% of rated voltage before commencement of the dielectric test. The no-load losses and current measured after completion of the dielectric test shall be the values used in determining the performance of the shunt reactor

- Impulse test shall be applied on all shunt reactor terminals, including neutrals. Impulse test oscillography records shall be made

- Noise level measurements shall be carried out according to IEC 60076

- Bushings shall be fully tested according to IEC 60137

- Insulation power factor tests shall be performed with bushings in place.

4.16.3 Type Tests

The following type tests shall be carried out. The tests shall be according to IEC 60076, except where otherwise specified.

- Temperature rise test

- Noise level

- Examination of harmonics

- Tests on bushings

4.16.4 Routine Tests

The following routine tests shall be carried out. The tests shall be according to IEC 60076, except where otherwise specified.

- Winding resistance measurements

- Polarity tests

- No-load loss at 90%, 100% and 110% of rated voltage

- Exciting current at 90%, 100% and 110% of rated voltage

- Load loss at rated current

- Separate source withstand tests
- Induced voltage tests
- Impulse voltage withstand tests. Full wave and chopped wave
- Pressure tests on tank and coolers for oil tightness. If a temperature test is made, the pressure test shall be made while the shunt reactor is still hot
- Operational tests of all devices and wiring
- Insulation tests on auxiliary devices and wiring
- Test on bushings

5.0 Studies Section

Engineering and performance studies shall be performed within the scope of supply. The Contractor shall perform design and simulation verification studies at its own facilities to ensure proper design and operation of the RPC system, which includes mechanically switched reactors (MSRs). The studies shall demonstrate that the RPC will perform according to the requirements of this specification. The Contractor will allow the Employer, his engineer or designated representative to witness, review and provide comment on such studies and simulations. These studies are in addition to the actual SVC design studies and performance tests.

The Employer will make available the fundamental frequency power flow and dynamic stability data bases in Siemens/PTI PSS/E format as the basis of these studies. The Contractor shall sign a release specifying that the data base is for the Contractor’s in-house use for this project only before the data bases will be made available. The data bases shall not be used for any purpose other than this project shall not be disclosed to any third party without written consent of the Employer and shall be destroyed after the warranty period for the SVC.

Contractor studies shall be based on models and data that accurately represent the SVC, fast voltage regulator, capacitor bank controls, timing, logic and limits to be supplied. The SVC model and data used for the Employer’s impact study were based on assumed data that may not represent the contractors SVC. It is expected that performance of the Contractor’s actual SVC model will more accurately represent the physical SVC to be supplied than the Employer’s assumed model and data.

5.1 Step Response Study

A simulation analysis of 1% step reference changes for system pre and post fault system conditions listed in Table 5.1 shall demonstrate the SVC’s linear response time under the pre and post fault system conditions.

5.2 Major Disturbance Response

A simulation analysis of the SVC including fast voltage regulator and reactor or capacitor switching shall demonstrate the SVC response and system recovery to the major fault disturbances listed in Table 5.1.

5.3 Major System Disturbances

The actual SVC, MSR and System response shall be demonstrated for various initial conditions for the following system disturbances and switching sequences.

Table 5.1 System Response

No.	Contingency	Location	Fault Clearing Times
1	3 Phase Fault	220 kV terminals of 220/110kV transformer at Kandahar East. SVC must return to service immediately and stabilize bus voltage between 1.1pu and 0.9pu.	0.15sec
2	3 Phase Fault	110 kV terminals of 220/110kV transformer at Kandahar East. SVC must remain in service and stabilize bus voltage between 1.1pu and 0.9pu.	0.5sec
3	Loss of Kabul SVC	Chimtala 110kV bus. Voltage must stabilize with 1.1pu to 0.9pu.	NA
4	3 Phase Fault	Mid-line fault between Kandahar 220kV bus and Qalat. Clear fault and take the circuit out of service.	0.2sec
5	3 Phase Fault	Mid-line fault between Chimtala and Arghandi 220kV circuit. Clear fault and take the circuit out of service.	0.2 sec
6	Line Energization	Lines and substation in WO-LT-0048. Steady state responses as described in the MSR Specification	NA
7	Line De-energization	Lines and substation in WO-LT-0048. Steady state responses as described in the MSR Specification	NA

5.4 Control Interactions

Studies indicated above in sections 5.1, 5.2 and 5.3 shall confirm satisfactory operation of the SVC regulators. In addition, these studies shall demonstrate satisfactory operation of any supplementary controls included in the SVC. The study shall demonstrate that there is no unfavorable interaction with other nearby control systems.

5.5 SVC Model

For the purpose of the above system studies, the Contractor shall develop and deliver to the Employer an accurate power flow and dynamic simulation models of the supplied SVC compatible with Siemens/PTI PSS/E Version 32. The Employer will use this model for future system studies. The model shall provide, as a minimum, the following features:

- Accurately represent the as-built operation and performance of the SVC for a time frame up to 60 seconds.

- Model shall provide the Employer with appropriate feedback on the various aspects of SVC operation during a simulation. The following are deemed minimum display requirements: SVC limit operation, SVC blocking, SVC restarting, and others deemed to be of interest by the Contractor.

- Clear and accurate documentation of the theory and modeling techniques (including assumptions) used for the model. Include examples for calculating and setting all Employer controlled parameters and data.

- Clearly documented model code throughout the model (liberal use of comments)

- Model documentation shall include a narrative description of model operation, model assumptions, model approximations, user instructions for the model, transfer functions and block diagrams illustrating model functions, logic diagrams, equations describing SVC relationships, and other items to clearly document the model.

5.6 Steady State Power Flow

Perform steady power flow studies using Siemens/PTI PSS/E Version 32 as required in Table 5.1.

5.7 Employer Provided System Model

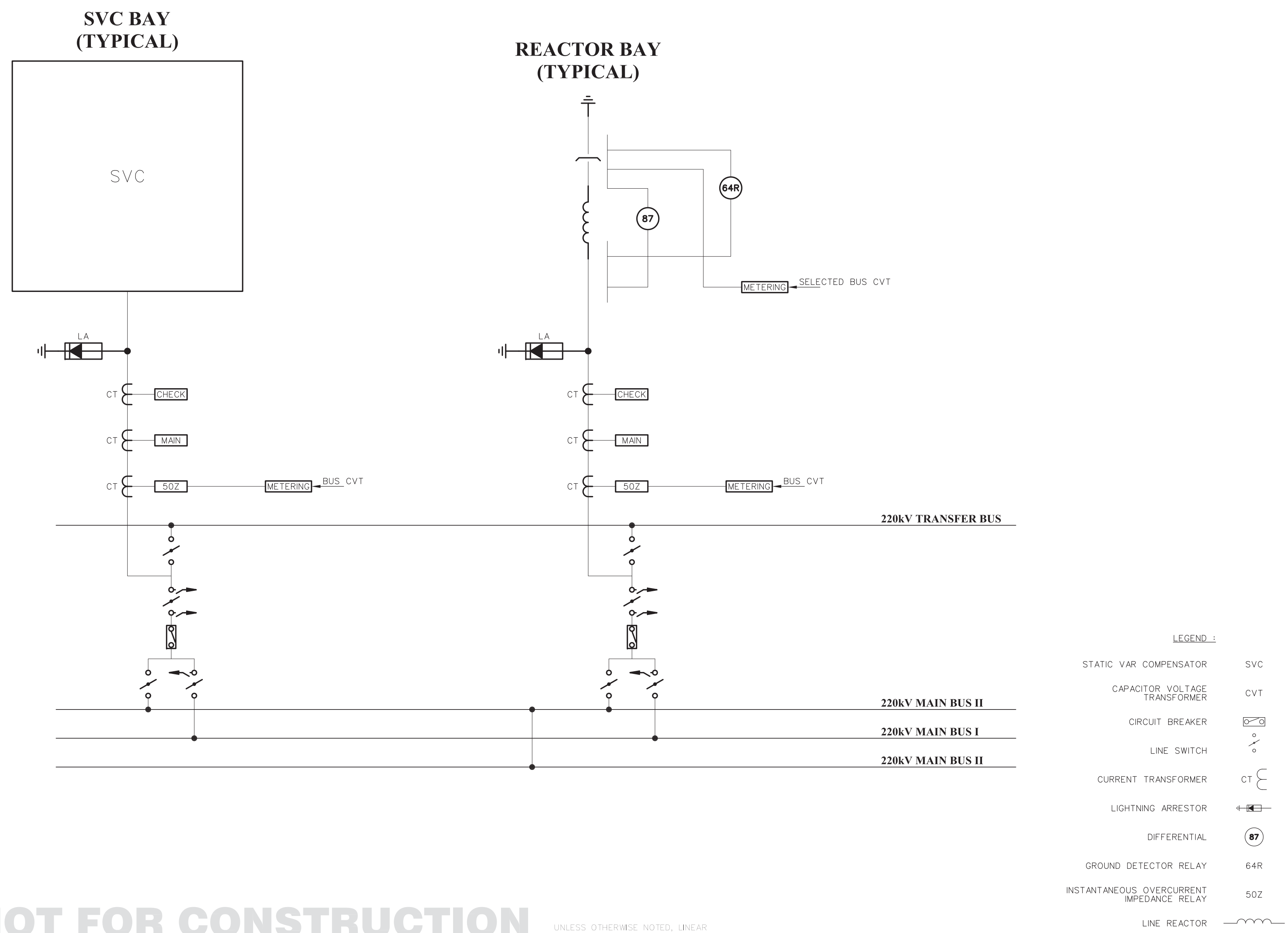
While a good faith effort has been made to provide an accurate representation of the system, the Siemens/PTI PSS/E models will, of necessity, be based in part upon representative or estimated data. The Contractor shall evaluate the impact of possible errors in the accuracy of model parameters and, following consultation with the Employer and/or Employer's representative, perform sensitivity analyses to evaluate the impact of changes in the most critical parameters. The Employer will provide a report and review the results of these sensitivity studies with the Employer and/or Employer's representative to determine if changes in design will be requested to account for the impact of potential errors in the model input parameters.

5.8 System Effects

Valve firing circuits shall be designed to be immune to rapid changes in the 220kV bus voltage amplitude and/or phase as may occur due to fault and clearing disturbances in the power system. This immunity shall be demonstrated by simulation tests of the SVC firing system and/or by high frequency (delta T equal to 50μs or less) simulation modeling of the SVC.

Appendices

Appendix A SVC One Line Drawing



NOT FOR CONSTRUCTION

UNLESS OTHERWISE NOTED, LINEAR DIMENSIONS SHOWN ARE IN MILLIMETERS.

DRAFT 6/28/2012 8:52 AM

This project was made possible by the United States Agency for International Development and the generous support of the American People through USAID Global Architecture and Engineering IQC Contracts.

CONCEPT DESIGN

USAID FROM THE AMERICAN PEOPLE

AESP

DESIGN/BUILD RFP

NEPS – SEPS ELECTRICAL TRANSMISSION

RPC SYSTEM TYPICAL ONE LINE

SHEET REFERENCE NUMBER:
LT0054-A1
E-001

USAID/Afghanistan
U.S. Embassy Cafe Compound
Great Masood Road
Kabul, Afghanistan
Tel: 202.216.6288
http://afghanistan.usaid.gov